THE HAWAIIAN PLANTERS' RECORD

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A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Twenty-five Years of Experiment Station Work

Dr. Walter Maxwell arrived in Honolulu on April 2, 1895, on the S. S. China to begin scientific studies of the problems of sugar production in Hawaii. As the first director of the Experiment Station he conducted investigations of such fundamental importance that his work has been constantly consulted by those who have followed him throughout the quarter century of Experiment Station activity in the application of science to sugar production.

In 1894 Hawaii produced 153,092 tons of sugar. So great a part has been played by hydraulic engineering, and mechanical engineering by the individual plantations, their managers and operators, that it is difficult to estimate even in a rough way the extent to which the Experiment Station work has contributed in quadrupling Hawaii's sugar output of twenty-five years ago. Nor is it necessary or desirable to make such an estimate. It is enough to know that Experiment Station work has established itself as an important auxiliary to the plantations and that it is un~~usu~~iversally recognized as such.

The Industrial Service Bureau

Through the cooperation of Mr. Donald S. Bowman, Director of the Industrial Service Bureau of the Hawaiian Sugar Planters' Association, the *Record* will in the future carry articles and illustrations pertaining to the work of this newly-organized bureau. The housing of the plantation laborer, his health and general welfare, together with the sanitary engineering problems pertaining to this subject, will receive their due share of attention.

In this issue Mr. Bowman has contributed articles dealing with the housing question, the milk supply of the plantations, and the fly, that menace to the health of man. Next month an article will appear on rat control.

Housing the Plantation Worker.

By Donald S. Bowman, *Industrial Service Bureau, H. S. P. A.*

The one-family house with fenced-in yard, sufficiently large for flower and vegetable gardens, has become the plantation standard. The newer type of dwelling with the bungalow or hip roof is finding much favor. This type of construction has much to recommend it, one of its advantages being better ventilation, as the overhanging roof protects the side walls, permitting the opening of the windows in all kinds of weather.

We show an attractive, convenient bungalow in vogue on Kauai which has much to recommend it. The interior finish is surfaced, the rooms are ceiled, cold water paint and stain are used for decorating, and the attached kitchen has a cement floor, built-in concrete stove with cast-iron top, and a sink of concrete. As will be seen, in the rear of the kitchen is a concrete wash floor surrounded by a concrete wall, the waste water being carried directly into an open concrete drain. This type of individual wash floor is much appreciated by the woman with small children, as she does not have to leave the little ones.

Groups of these bungalows fronting on streets, with yards large enough for a lawn and garden, go to make up the ideal plantation village and are a great contrast to the white-washed barracks of the old plantation camps. On all estates where the bungalows have been erected, great satisfaction is expressed by both the managers and occupants.

In considering housing, many details must be taken into account, such as materials, plans, location, water supply, sewage and waste water disposal, the building

Kauai Bungalow. Note overhanging roof, protecting the sides; concrete floor; kitchen with concrete stove pipe in rear; concrete wash house attached; kitchen roof could be carried over for protection from sun and rain.

Bungalows, showing old and new types of roof construction. These buildings are stained, are attractive, and are situated with good distance between buildings. Ample garden space is provided in rear.

and sanitary laws, etc.; and the buildings should be so constructed as to make the handling of an epidemic of contagious or infectious disease easy. As an example, no double walls or other rat harbors should be permitted, thereby preventing to a large extent plague infection.

In years gone by very little attention was paid to location, the chief consideration being that no cane lands be used. Now, thanks to the home-building idea as expressed in new construction, we have model villages in place of camps.

Pleasant surroundings, with some of the modern comforts and conveniences go a long way to make the worker healthier and more efficient in his work.

Milk as a Food.

By Donald S. Bowman, *Industrial Service Bureau, H. S. P. A.*

Many of our plantations maintain dairy herds for the benefit of their employees, supplying milk at the cost of production. This good work should receive every encouragement, and those plantations which have no dairy herds would do well to consider milk in the light of a most necessary food.

Milk is as near a perfect food as it is possible to obtain, as it contains all the essential elements for normal growth and development. We find it contains the materials necessary to maintain the living tissues of the body, i. e., proteins, and enough of the fats, starches, sugars and mineral substance to furnish energy and growth. Milk contains also a substance whose nature is not yet fully under-

stood, but whose presence in the diet has been demonstrated to affect body growth in animals or man. These substances are known as vitamines, growth determinants, or the unknown dietary factors.

Clean milk fulfills all of the requirements for an adequate food better than any other single foodstuff, and it is the food most needed on the plantation and in a great many instances the hardest t o obtain. Infant mortality would be decreased and a healthier lot of youth would result were more pure fresh milk used as food, and not considered in the light of a beverage for the older children. Milk as a source of energy, or as fuel for the body, compares most favorably with other foods.

The energy value of a quart of milk is about equivalent to that of a pound of lean meat or of eight eggs. As a source of energy, cereals are, however, cheaper generally than either milk, meat or eggs, and therefore cereal and milk is the ideal combination of foods to furnish energy in childhood.

Of all foodstuffs, milk is the cheapest and most abundant source of obtaining the essentials for bone formation and growth. Therefore milk should form a large part of every child's diet. How often have we seen ignorant mothers bringing up infants on a diet of coffee or tea to which was added a small amount of canned milk!

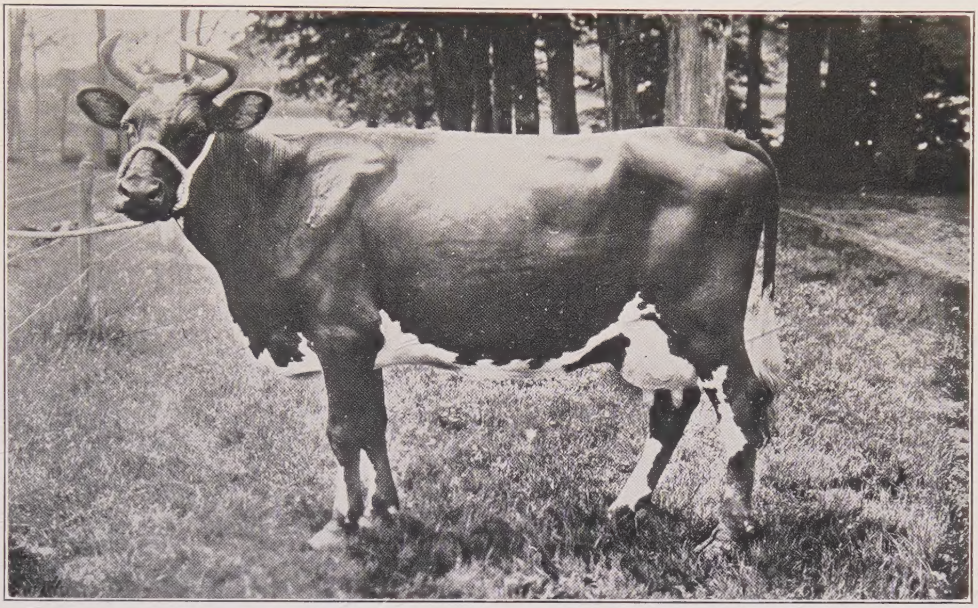
A well-regulated sanitary dairy would be a great asset to every sugar estate, and if we are to look to the future health and well-being of the employees, this subject should receive early and careful consideration. Attention is invited to Ralph Borden's excellent article on "Dairying in Hawaii" as a source of information, which will be found in the Industrial Service Bureau file.

The Ayrshire Cow.

The Secretary of the Ayrshire Breeders' Association has recently supplied us with a photograph of an Ayrshire cow, which holds an exceptional record as a milk producer. The following information, accompanying this photograph, is published for such interest as it may possess in connection with the plantation dairy:

" 'She's a grand wee Coo,' and all dairymen irrespective of breed will pay their homage to Lenetta, the twenty-one-year old Ayrshire who has just completed an Advanced Registry record amounting to 11,138 lbs. milk, 374.73 lbs. fat. In the face of present-day world records, 11,138 lbs. milk, 374.73 lbs. fat, would be considered just an ordinary production, but, nevertheless, it is a world record over all breeds, for no cow of any breed has ever equalled that record officially at the age of twenty-one years.

"Lenetta illustrates Ayrshire persistency and the breed's ability to produce and reproduce. She was born August 16, 1898, and was bred by A. A. Hunnewell of New Gloucester, Me., and is owned and was tested by Dr. John A. Ness of



Lenetta, the 21-year-old Ayrshire cow.

Auburn, Me. As a fourteen-year-old she officially tested 13,248 lbs. milk, 465.74 lbs. fat. She now has five A. R. records to her credit, averaging 11,472 lbs. milk, 397.36 lbs. fat, all of the five records being made after fourteen years of age. She has been a uniform producer, her average of 11,472 lbs. milk comparing well with last year's record of 11,450 lbs. milk and this year's record of 11,138 lbs. Lenetta is a strong, vigorous cow in spite of her years, and looks capable of continuing the good work for quite a few years yet. She has been a regular breeder.

"Cows of this type are the backbone of the dairy industry."

[H. P. A.]

New Intermediate Conveyor.

An idea, which has been in the mind of Chief Engineer Joseph Meinecke, of the Maui Agricultural Company, for several years, has taken concrete form this season as the *Meinecke Intermediate Chute Conveyor,* patented, illustrations of which are shown in Figs. 1 to 4. The photographs show two of the conveyors installed in the Maui Agricultural Company's mill, and the parts of one of the old slat conveyors which was discarded.

One of the greatest sources of annoyance to mill engineers, and of time lost in grinding, is the intermediate conveyors. As soon as the chains begin to wear, their breakage causes frequent shutdowns on the mills, with consequent increase in cost of manufacture. On some mills 75% of the shutdowns are due to the intermediate carriers.

The new conveyor has no moving parts, but is simply a chute built on

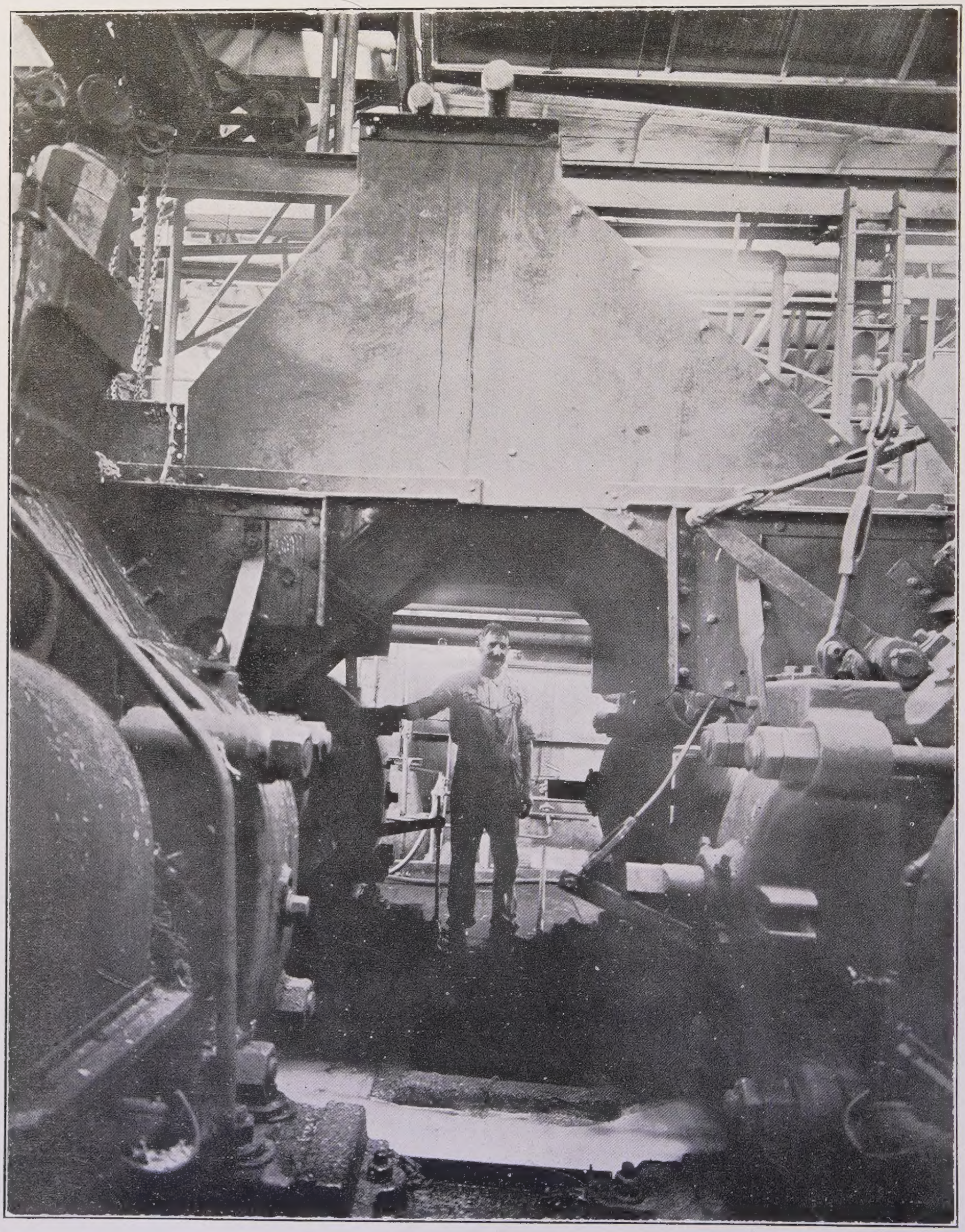


Fig. 1. Meinecke Intermediate Chute Conveyor for Cane Mills. Side view.

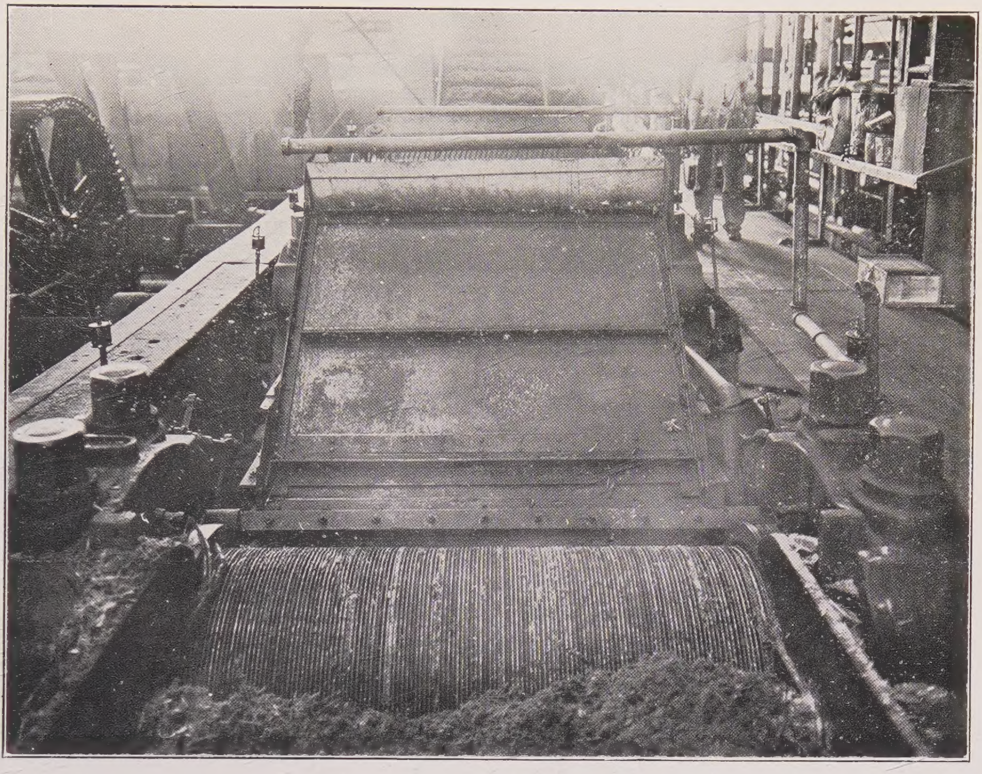


Fig. 2. Meinecke Intermediate Chute Conveyor. Back view.

Fig. 3. Meinecke Intermediate Chute Conveyor. Front view.

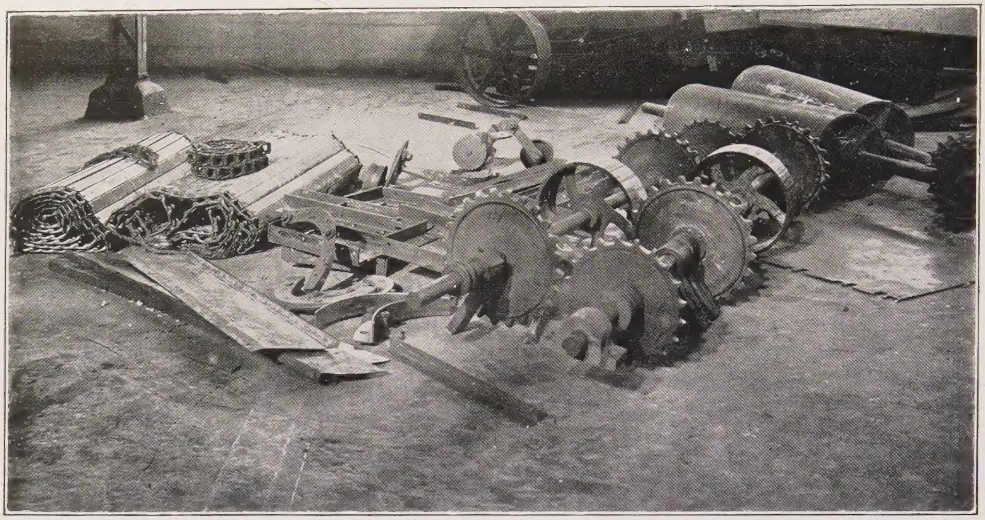


Fig. 4. Machinery replaced by one Meinecke Intermediate Chute Conveyor.

proper lines. The mill itself forces the bagasse up in the conveyor to a certain height, from which it falls into the next mill. As there is nothing about the conveyors to get out of order, and they work automatically, they require no attention.

R. S. N.

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Note on Pineapple Wilt Disease at Kuoolono Park, Kauai.

By C. W. Carpenter.

A recent observation by Mr. W. D. McBryde of Kauai is of interest in relation to a possible means of control of the pineapple "wilt" disease. A section of young pineapple plants sprayed with Bordeaux mixture several times for the control of "heart-rot" early in 1918, at the writer's suggestion, is now found to be not only free from "heart-rot," but also comparatively free from "wilt." The surrounding areas of plants, which so far as can be determined have the same history except that no Bordeaux was applied, are suffering badly from the "wilt."

It seems incredible that the present difference in the appearance of the respective plots of ratoons could be the result of a few sprayings with Bordeaux applied to the plant crop nearly two years ago, when the plants were some nine months old, but since the application of the Bordeaux appears to be the only factor which can be held responsible, the history of the case is briefly recorded for what it may be worth. It should be pointed out, however, that the data are indeed meager, and inferences and conclusions as to the value of this treatment should be held in abeyance until such time as more exact experiments shall furnish a more substantial basis.

In November, 1917, several pineapple plants affected with "heart-rot" were submitted to the writer by Mr. McBryde with a request that the matter be investigated. This trouble was diagnosed as due to bacteria working in the tender tissues at the base of the young central leaves. The field was visited, and since a relatively small number of plants were as yet affected, scattered here and there over a restricted area of several hundred square feet, it was recommended that Bordeaux mixture be sprayed on the affected rows, together with the adjacent sound rows of plants at each side. The plants were some nine months old with open crowns, and it was thought that small accumulations of Bordeaux in the central leaf bases would prevent any further spread of the "heart-rot" disease.

The pineapple field under discussion occupies the gentle slope of virgin grass land makai of Kuoolono Park. Some forty rows running across the face of the slope were sprayed, leaving large areas of untreated healthy plants both above and below. It was advised that the spraying be begun with a weak Bordeaux, gradually increasing the strength when it was found the plants would stand it. Accordingly, Bordeaux spray was applied as follows at intervals of about ten days: copper sulphate, 2 pounds; quicklime, 2 pounds; water, 50 gallons, applied twice. The 3-3-50 formula was applied three times, and the 3½-3½-50 formula twice.

Upon inquiry May 24, 1918, as to results, Mr. McBryde wrote me as follows regarding the "heart-rot" disease, no mention being made of "wilt" disease: "My man in charge sprayed the plants with the Bordeaux mixture and increased the strength from time to time when he found the plants could stand the stronger spray. The disease (heart-rot) finally disappeared, whether due to the spray or climatic conditions I am unable to say; at any rate, we are not troubled with the disease at this writing."

It has been noticed for some time now that in the section where the spray was applied, the plants were larger and more vigorous, and the plant crop of fruit was more uniform. The color of the plants is much better and contrasts markedly with the rest of the field above and below, which is suffering from a bad attack of "wilt" disease. Since the spraying early in 1918 is the only factor in Mr. McBryde's judgment wherein this good section differs in culture from the rest of the field, he is convinced that the spray has in some way been instrumental in maintaining the health or enhancing the vigor of these plants. It is understood that on the strength of his findings large areas will soon be sprayed experimentally by him and by others to determine if Bordeaux mixture is indeed of any value in preventing "wilt."

When it is recalled that in our present judgment "wilt" is caused by a parasitic root fungus (allied to *Pythium*) active under as yet unappreciated soil conditions, it appears probable that if Bordeaux is of value it will be chiefly so as a preventive through increasing or maintaining the vigor of the plants in new plantings and unaffected or but slightly affected "wilt" fields, and cannot be expected to rescue plants in the final stages of "wilt."

Whatever benefit may have resulted in this case from applications of Bordeaux mixture seemingly is a result of the stimulating action of the copper upon the chlorophyll, etc., of the leaves. There is considerable foundation in the literature for the belief that entirely outside of the realm of plant diseases, etc.,

copper sprays exert a beneficial action upon the starch-manufacturing apparatus of the leaves. To quote from Strassburger's "Text-Book of Botany": "It has been discovered that by the presence of certain substances in themselves of no nutritive value, the absorption of actual nutritive matter is increased. In the case of the very poisonous copper salts, experience has taught that when they are brought into contact with the leaves * * * they exercise a beneficial influence on the formation of chlorophyll and increase assimilation, transpiration, and the length of life."

It is not considered that sufficient evidence has been brought forward in the literature to show that Bordeaux mixture acts as a chemical stimulus, and whatever benefit may result from the application of this spray to the leaves of plants, beyond its fungicidal and insect-repelling qualities, may possibly be attributed to some other factor than the stimulating action of the copper constituents. The well-known neutralizing power of soils toward metallic salts renders it extremely improbable that sufficient toxic material reached the soil in the brief sprayings mentioned to be active as a fungicide therein.

H 400 Varieties at Waipio.

We have recently harvested at Waipio a series of the so-called H 400 varieties. In the same lot was also included a few plots of Badila. The cane was first and second ratoons, 18 months old when cut. The yields were as follows:

Variety	Yield per Acre		
	Cane	Q. R.	Sugar
H 460	87.4	8.99	9.72
H 431	75.5	7.93	9.52
H 425	86.2	9.13	9.42
H 466	89.7	9.54	9.40
H 427	73.4	7.99	9.18
Badila	78.7	8.57	9.18
H 416	76.8	8.38	9.15
H 465	70.2	7.80	8.99
H 409	72.4	8.62	8.40
H 441	64.2	9.57	6.71
H 463	63.2	10.09	6.26
H 464	57.8	10.28	5.62

H 411 and H 409 are not of much promise for Waipio conditions. H 464 at first gave indications of being a fair cane, but it has now gone back, suffering from what appears to be Lahaina disease.

In the following table is given a summary of the yields of these varieties for three crops, one plant and two ratoons:

SUMMARY OF RESULTS FOR THREE CROPS.

Variety	1917 Crop 14 Months Plant			1918 Crop 14¾ Months Ratoons			1920 Crop 18 Months Ratoons			Average Three Crops		
	Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Q. R.	Sugar
H 460	56.8	8.41	6.76	60.9	8.78	6.94	87.4	8.99	9.72	68.4	8.76	7.81
H 466	50.0	8.87	5.64	56.8	8.33	6.83	89.7	9.54	9.40	65.5	9.00	7.29
H 465	44.5	8.02	5.55	54.7	7.47	7.31	70.2	7.80	8.99	54.8	7.53	7.28
H 425	41.3	8.51	4.86	50.5	8.34	6.05	86.2	9.13	9.42	59.4	8.78	6.77
H 427	35.5	7.73	4.60	51.2	7.93	6.45	73.4	7.99	9.18	53.4	7.92	6.74
Badila	45.5	7.91	5.75	40.1	7.89	5.08	78.7	8.57	9.18	52.9	7.93	6.67
H 463	46.4	8.33	5.57	54.2	8.19	7.65	63.2	10.09	6.26	54.6	8.41	6.49
H 431	32.5	8.12	4.00	44.5	8.16	5.48	75.5	7.93	9.52	50.8	8.03	6.33
H 416	28.3	8.35	3.39	49.6	8.13	6.11	76.8	8.38	9.15	51.6	8.29	6.22
H 411	48.1	8.33	5.78	48.0	10.01	4.81	64.2	9.57	6.71	53.4	9.25	5.77
H 409	26.8	9.16	2.93	47.2	8.64	5.50	72.4	8.62	8.40	48.8	8.69	5.62
H 464	46.5	9.03	5.15	49.6	8.21	6.04	57.8	10.28	5.62	51.3	9.19	5.60

In the above list H 460 leads in the average production of sugar for the three crops, having been fairly consistent throughout.

H 431 and H 425 are worthy of note in that they seem to be improving. H 431 was tenth in order of sugar production in the plant crop in 1917, while in this year's harvest it was second; H 425 was eighth in 1917 and third this year.

H 416 is also much better now than it was in the first two crops. This would indicate that these canes have good ratooning qualities.

H 427 and H 465 deserve attention for their good juices. Both of these canes are consistently better than Badila in the quality of their juices.

J. A. V.

Observations on Applications of Mud Press Cake.

The following analyses of mud press cake, based on dry weight, have been made for experiments where this material was being tested:

	% N.	% P_2O_5	% K_2O	% Moisture
Paauhau Exp. 13 (1917).........	2.40	5.88	0.27	13.72
Paauhau Exp. 14 (1919).........	2.63	9.05	0.14	27.80
	2.59	7.71	0.21	58.00
Wailuku Exp. 7.................	1.16	6.96	0.31	55.92
Oahu Sugar Co. (Waipio Exp. F.).	1.41	4.41	0.46	74.18
Average	2.04	6.80	0.28	
Lbs. per Ton of Dry Material.	40.80	136.0	5.60	

We note from the above the amounts of nitrogen, phosphoric and potash in the mud press cake vary greatly in these samples secured from three widely-separated localities.

Considering the fact that all plant food represented is in an available form, we have a good fertilizer, and if we apply about 10 tons of press cake (60% moisture) per acre, we are giving the cane 163 pounds of nitrogen, 544 pounds of phosphoric acid, and 22 pounds of potash per acre. For most places this should satisfy the plant food requirements of cane.

In the following table are given the amounts of nitrogen, phosphoric acid and potash that would be contained in 5, 10, 20 and 30 tons of mud press as reported above, assuming the mud press to contain 60% moisture when applied:

Amount of Mud Press	Pounds of Nitrogen	Pounds of Phosphoric Acid	Pounds of Potash
5 tons	82	272	11
10 "	163	544	22
20 "	326	1088	45
30 "	489	1632	67

J. A. V. and W. P. A.

Destroying Nut Grass.*

Mr. F. Lan. Nott ("The Grange," Woongarra, Bundaberg), in reply to an inquiry by the Director of the Experiment Station (Queensland) concerning a coccid insect attacking nut grass, wrote as follows:

"When starting the cultivation of cane on my farm, I was greatly troubled with nut grass, which was distributed over about 30 acres, which thrived in ratio to the cultivation, and I experienced great difficulty in raising payable crops of cane. Usually, the crop had to stand over and thus become a two-years' crop. This, I may say, always happened in what is known as the plant crop, but ratoon crops were usually cut at twelve to thirteen months. Naturally, the loss through this delay, compared with crops on the same quality of land free from the weed, was very great; also, the amount of extra cultivation cost was severely felt.

"I had come to the conclusion that I would throw the land out of cultivation, but at last obtained some coccid insects on some nuts from a locality where I had heard that a trial (and a failure) had been made for the eradication of this pest by this means.

"I started with spreading 'diseased' nuts at about 8 yards apart over four-fifths of an acre, and allowed these to remain without disturbing them for two months, when the land carried a beautiful crop of nut grass. I then plowed it up and harrowed it to better distribute the parasite (which had considerably increased in numbers), and planted the land with lucerne, and watched the progress of the disease.

"Naturally, when the lucerne grew vigorously, little nut grass was to be seen. However, from observation I was satisfied that the parasites were behaving well. After about fifteen months I removed the lucerne, and expected to see, at least, a considerable return of the nut grass plants, but very few came, and those few were all weak and eventually disappeared.

"As control, I had the adjoining land on three sides of a rectangular plot, and on the eastern side was a road, which effectually prevented the parasite from extending in that direction, but they spread to the south side.

"Since that time I have had splendid results from the treatment, and am sure that, if carefully applied, the results are well worth the time spent on the trial. The following are the cardinal points to be observed:

"1. See that there is a good crop of nut grass.

* Queensland Agricultural Journal, Nov., 1919, p. 223.

"2. Distribute the coccid as evenly as possible.

"3. After distribution, plant a cover crop, or, at least, do not disturb the soil. This last remark is important, as by cultivation the coccid is killed before the nuts.

"Up to the present I have eradicated the pest on 20 out of the 30 acres, the time taken being four years from the commencement. The most difficult part is to stop the plant from spreading around the fringe or boundary of the land, as the coccid cannot travel from one patch across a wide gap to another.

"During the first two pears I kept a sharp lookout, as the remedy might have taken to other and desirable plants, but so far I have not seen it live and generate on any other plant. I do not think there would be any danger by its introduction, nor should there be any trouble in introducing the coccids, as they can easily be transported on the nuts.

"I know of one place in Queensland and one in New South Wales where it was tried, and both of these would report failures—failures which, in my opinion, were caused by expecting the insect to work miracles and by a want of knowledge of the life history of the insects. My experiments were carried out on red volcanic soil of a heavy nature, with a climate usually dry in spring. From the beginning of operations to the killing out of the nuts should not take more than three years. When the insect has been distributed, allow the land to go into grass, or put in a cover crop, but do no after cultivation for the time mentioned."

[H. P. A.]

Experiments in the Eradication of Nut Grass.*

This plant (*Cyperus rotundus*) is one of the worst weed pests in the Hawaiian Islands. It spreads by seeds when these are allowed to form, but aside from seed production, it produces underground corms up to 12 mm. diameter in size which possess the ability to reproduce the plant under remarkably adverse conditions.

An attempt was made to eradicate nut grass by cultivating sufficiently to prevent any growth above ground. The field was harrowed or disced about once every three days, depending on the amount of rainfall and resultant rate of growth. The experiment was started August 10th and continued to December 6th of the same year, when continued rains made the field in question so muddy as to make continued cultivation impracticable. From time to time thirty representative nut-grass corms were selected and weighed to note whether preventing growth above ground was actually reducing the size and hence the vitality of the corms.

Date	Weight of 30 Nut-grass Corms	Average Weight of One Corm	Days Since Beginning Clean Culture
August 10	27.3 grams	0.91 gram	0
October 18	12.9 "	0.43 "	69
December 6	9.0 "	0.30 "	118

* College of Hawaii Bul. No. 5.

At the time it was necessary to discontinue the experiment the growth of the grass showed that there was still plenty of vitality left in the corms. However, reduction to one-third of their original size in 118 days shows the effect of the starving process.

On February 10th, 64 days after cultivation had been discontinued, thirty corms selected from the same field showed an average weight of 0.74 gram each, indicating the rapidity with which food material is stored in corms when the tops are allowed to grow unchecked.

The corms exposed to air and sunshine lose about 30% of their weight in three weeks. An average corm as taken from a reasonably dry soil contains 53% moisture. Four nut-grass corms placed in good soil and allowed to develop produced plants two feet high in 42 days.

Six nut-grass corms in a soil that was flooded with water for 32 days produced strong, vigorous shoots four days after they were taken out of the water-logged soil. [W. P. A.]

The Kudzu—An Interesting Legume.

The Kudzu plant, a legume imported from Japan, was recently found locally by Mr. E. J. Mooklar in a Chinese garden on King Street, Honolulu. We are planting this legume in Manoa in order to supply cuttings to those who may wish to give it a trial. The Fiji Planters' Journal,* under the heading, "Kudzu, a Great Fodder Plant", describes it thusly:

"This plant is a native of Japan, where it is a leading crop, and is highly commended by the United States authorities. This is a perennial vine, and its numerous merits compared with lucerne, which is styled the 'King of Fodder Plants', are many. It succeeds in any class of soil, if drained; does not require any fertilizer; it rapidly enriches poor soil; it does not require to be cut at a certain time to save it. It will transform poor soil, or barren hillsides into profitable use; it makes good permanent pasture and it is not injurious to stock at any stage—either green or dry—and when fed to cows it will produce more and richer milk than any other single feed, as it is more nutritious than either lucerne or bran. It is said that in the United States it has produced four cuttings of two and a half tons each per acre annually. It is very drought-resistant, as it roots deeply, and the vines cover the ground with foliage which acts like mulch and conserves moisture. It is also said that land planted with Kudzu soon becomes like the rich soil that has recently been cleared from the virgin forest, and it becomes richer each year through the large quantity of nitrogen deposited therein. It should be cultivated in rows eight feet apart the first season, after which it will require but little attention."

From Bailey's Encyclopedia of Agriculture† we quote this account of the "Kudzu Vine":

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* B. Harrison, F.R.H.S., Burringbar, N. S. W., Vol. V, No. 47, p. 182.

† Vol. V, p. 2856.

A Kudzu Plant, grown in a Honolulu garden.

"PUERARIA (M. N. Puerari, botanist of Geneva). LEGUMINOSAE. P. Thunbergiana. Dolichos japonicus. KUDZU VINE. Perennial, with large tuberous starchy roots, making a vigorous growth of slender hairy, twining stems. A hardy vine remarkable for the great rapidity of its growth, and most useful for covering arbors and verandas. It is also used as a forage plant. From a well-established root, vines will grow 40-60 feet in a single season, producing a profusion of very large leaves. In the north the plant dies to the ground in the winter, but in the south the top becomes woody. The large fleshy root assumes most curious shapes, the main branches often being 4-5 feet long. Georgeson writes of the plant in Japan: 'The roots are fleshy and yield starch of excellent quality; the tough fiber of the inner bark is manufactured into a sort of cloth which combines fineness with remarkable strength; and in certain situations the vine is unparalleled for ornament and shade.' Propagated by division of the roots, or by seeds when they can be had; also by cuttings." [H. P. A.]

Manufacture of Nitrate of Lime in Norway.*

While the principle of the process used in Norway for the production of nitrates from atmospheric nitrogen is generally understood, it would be difficult without actual inspection to form anything like an adequate conception of the magnitude of the industry. A total of 300,000 to 350,000 horsepower, rendered available from waterfalls, is now in use in the synthetic manufacture of nitrates. The first factory was established at Notodden in 1905, but Rjukan, where works were also opened in 1911, and considerably extended after the commencement of the war, is now the chief center of the industry. A few practical details about the manufacture of nitrate of lime at the latter place may serve to convey some idea of the nature and proportions of the enterprise.

Rjukan I, as it is called, to distinguish it from the newer works there, is in reality the largest water-power station in the world (140,000 horsepower). The current from there is conducted to the furnace-house through 60 cables of a length of three miles each. By means of blowers 1000 million gallons of air are at Rjukan driven through the electric furnaces every 24 hours. The heat in the furnaces, exceeding 3000° C., brings about a combination of the nitrogen of the air, resulting in the formation of nitric oxide (NO). These hot gases (800° C.) are used as fuel in large steam boilers, where the temperature is reduced approximately to 250° C. By water-coolers the heat of the gases is further reduced to about 50° C.

The subsequent retention of the gases for some time in large oxidation tanks results in the transformation of nitric oxide (NO) to nitrogen dioxide (NO_2). The gases are next conveyed through three granite towers, 23 meters high, and filled with quartz sprinkled with water. This operation causes the absorption of the nitrogen dioxide by the water with the production of weak

* The American Fertilizer, Jan. 17, 1920.

nitric acid (30 per cent). This acid is then passed over limestone, and a solution of nitrate of lime is thus obtained.

The weak solution of nitrate of lime is next concentrated by evaporation until it contains 13.1 per cent nitrogen. The liquid nitrate being now thick is passed over revolving cylinders, which are internally cooled; the nitrate is here rapidly solidified and is taken off in leaves. The leaves of nitrate are then granulated in small mills. From high silos the nitrate in the finished state is filled into barrels of 100 kilos net weight. At Rjukan alone the normal daily production is 2000 barrels.

It may be of further interest to mention that Rjukan, where the barrels themselves are made, possesses actual facilities for making 5500 and packing even 6122 barrels daily. What this means may be illustrated by the fact that the staves required for this number of barrels would, if placed end to end, extend over 80 miles, and the iron for the hoops over 20 miles. By working at full pressure it is possible with the existing facilities to fill a cask every one-sixth of a second. [J. A. V.]

Ratooning in Australia.*

A method of ratooning sugar cane used at the Mackay Sugar Experiment Station, in Australia, has given large yields of ratoon crops. It is as follows:

It is believed that the best method of securing large yields of ratoon cane is to adopt the following procedure: Immediately the trash is burnt, open up the middles of the rows to a depth of 9 inches with the swing plow; next subsoil these two furrows so that a further depth of 6 inches in thoroughly stirred. Next plow away from the cane rows on to the middles and again follow with the subsoiler. By this means the whole of the ground between the rows has been moved and stirred to a depth of 15 inches; and the benefit to the ratoons in thus breaking up the hard ground and letting in air and sunlight is difficult to overestimate. Subsequent shallow cultivation with broad hoes should now be practiced frequently, in the same manner as recommended for the plant crop.

The results obtained at the Experiment Station, due to this method of cultivating ratoons, are detailed in the table below:

* Queensland Agricultural Journal, Dec., 1919.

Crop	Yield of Cane per Acre where the ground between the rows was plowed and subsoiled	Yield of Cane per Acre where the ground between the rows was only plowed to 8 inches
	English Tons	English Tons
First Ratoons	38.9	27.0
Second "	31.3	19.2
Third "	20.4	9.91

These experiments were not fertilized.

[W. P. A.]

Rats Killed by Fright.*

Varnish as Death-Trap.

As the result of experiments carried out by his department, Dr. Howarth, Medical Officer for the City of London, is now able to recommend varnish as one of the most effective ways of destroying rats on a large scale.

In an interview yesterday, Dr. Howarth explained that the substance used is strong lithographic varnish. It should be warmed by heating the container holding it, in boiling water. When warm the varnish will run, and in this condition it should be spread one-sixteenth to one-eighth of an inch thick on pieces of strawboard or fairly thick cardboard measuring about 15 in. by 12 in. A margin of about an inch should be left clear of varnish, and the bait placed in the center of the board where it will adhere to the varnish. The traps should be placed along the rat runs, or near the holes. They remain effective for about four days, when the old varnish should be scraped off and a fresh layer applied.

"We are continually faced with the rat problem in the City," said Dr. Howarth. "We first discovered varnish being used in a place in Fenchurch Street. Since then we have experimented very successfully. In some cases we have had 'bags' of 60 and 80, and I can recommend it as an excellent means of ridding a place of rats. Disappointments arise chiefly through the varnish being too weak or too 'tacky.' This allows the rats to move on it with impunity. We are endeavoring to meet that possibility by standardizing the quality of the varnish. People should continue to put down the boards so long as they are catching rats. It does not matter if a board has had a dead rat on it. They should just remove the body and put on more varnish.

"The varnish is not poisonous, and a coroner's jury would probably ascribe death to natural causes following a shock," continued Dr. Howarth. "I think that the rats die of fright. Once their tails stick their doom is sealed. They never

* From the London Times.

get near the bait. They get their feet in the varnish and the more they struggle the faster they stick. Rats caught during the night are always dead in the morning, and it is a very remarkable thing that if two rats get on to the varnish together one of them kills the other. Evidently each thinks that the other is holding him. Then there is a battle royal, and we find one with its neck bitten through. As to the cruelty of it, we cannot afford to waste sentiment, and it is certainly not as cruel as phosphorous poison, which takes about four hours to kill."

Dr. Howarth produced a couple of the traps with the victims of his experiments. In each case the bait was untouched, the rats having stuck immediately they touched the varnish. The Public Health Department at the Guildhall is ready to furnish information and to recommend manufacturers for supplying the varnish. [H. P. A.]

Plant Food.*

It might be well to begin by defining a few terms. First, then, what do we mean by "Plant Food"? According to the Standard Dictionary, food is defined as "any substance that, being taken into the body of animal or plant, serves, through organic action, to build up normal structure or supply the waste of tissue; nutriment * * *" As a second definition of "food," we find—"that which increases, keeps active, or sustains." Turning to "nutriment," we find it defined as "that which nourishes; that which promotes the growth or repairs the natural waste of animal or vegetable organisms; food." This last definition would seem to include as plant food, light, air, water and heat, as well as the so-called elements of plant food, which we ordinarily think of first when using this term. It seems to me a significant fact that we read in the account of the creation of Genesis, that God first created light, then air (firmament), then water and land, then said, "Let the earth put forth grass, herbs, yielding seed, and fruit trees bearing fruit after their kind, wherein is the seed thereof, upon the earth: and it was so." Then He set the lights in the firmament, among them the sun as a source of light and heat, and to control the seasons. The term "chemical requirements of the plant" would then seem to properly include: light, heat, air, water, and the so-called "elements of plant food," or plant food elements.

As man can not generally control the light, heat and air necessary for most cultivated plants, and in many cases not even the water, we shall confine our attention to a brief consideration of the plant food elements, considering the air and water only in so far as they furnish these elements.

"Elements" and "Substances."

Now as to the meaning of the term "element." Sir Robert Boyle (1627-

* Dr. R. N. Brackett, Clemson College, Short Course for Fertilizer Salesmen. From Commercial Fertilizer, Dec., 1919.

1691) defined an element as "the constituent of a compound substance which can be readily prepared, but which can not be further decomposed." Lomonossov, a Russian author, statesman, and chemist (1711-1765), in 1741 first drew a distinction between simple and compound substances, according to Dr. Alexander Smith, one of the leading chemists of the United States; a distinction more accurately drawn by Lavoisier, the great French chemist, in 1789.

By the way, I may say that the term "substance" is used by the chemist to designate a homogenous simple or compound material. Lomonossov is also credited with the enunciation of the first and most fundamental law of chemistry: "Every material can be described as being composed of one substance, or as being a mixture of two or more component substances, each of which has a definite set of specific physical properties."

Dr. Smith himself defines an element as one of the simple forms of matter, either free or in combination, and states that "simple or elementary substances are substances which we are not able, at will, to decompose into other substances, or to make by chemical union from other substances."

We now know about 83 such elementary substances. Taking the atmosphere, all terrestrial waters, and the earth's crust, so far as it has been examined, F. W. Clarke has estimated the plentifulness of the various elements. The first twelve, with the quantity of each contained in one hundred parts of terrestrial matter, and constituting together 99 per cent, are as follows: Oxygen, 49.85; silicon, 26.03; aluminum, 7.28; iron, 4.12; calcium, 3.18; sodium, 2.33; potassium, 2.33; magnesium, 2.11; hydrogen, 0.97; titanium, 0.41; chlorine, 0.20; carbon, 0.19.

Thus oxygen accounts for nearly one-half of the whole mass; silicon, the oxide of which is when pure quartz and in less pure form constitutes ordinary sand, makes up one-half of the remainder. Valuable and useful elements, like gold, silver, sulphur, and mercury, are among the less plentiful, which, all taken together, furnish the remaining one per cent.

Essential Elements.

The following 14 elements are found to be essential in building up the structure and in making good waste of animals and plants: oxygen, hydrogen, carbon, nitrogen, sulphur, phosphorus, gallium, magnesium, potassium, iron, sodium, chlorine, silicon, fluorine. To these is sometimes added manganese, but it is doubtful whether the last four and manganese are necessary to plant growth, so that the plant food elements might be restricted to 10. About 98½ per cent of the plant consists of hydrogen, oxygen and carbon, based on its entire composition. The dry matter of plants contains from 1½ to 7 or 8 per cent of ash. The elements found in the ash are, calcium, potassium, magnesium, sodium, iron, phosphorus, sulphur and silicon, sometimes manganese and aluminum, and occasionally other accidental constituents. The amounts of the ash elements is so small when compared with the composition of the whole plant, that at one time, they were considered accidental and unessential, indeed, until Liebig proved that they were essential to the growth of plants. We now know that the chemical requirements of the plant involve and include light, heat, moisture, all of which are intimately connected with the good physical condition of the soil, as well as

favorable biological conditions, together with an adequate supply of all the above-named elements in forms available for use by the plant.

Elements taken from the air: The composition of pure, normal, dry air is usually given as: By volume, nitrogen, 78.12; oxygen, 20.941; argon, 0.937; by weight, nitrogen, 75.539; oxygen, 23.024; argon, 1.437. But the atmosphere is a complex mixture of oxygen, nitrogen, carbon dioxide, argon, moisture, which are always present; oxides of nitrogen, and of sulphur, and their acids; ammonia compounds, dust, both organic and inorganic. While necessary to the germination of seed and the growth of the plant, it is not believed that the free oxygen in the atmosphere is used by plants in building up their tissue, but that they obtain their oxygen and hydrogen largely from water, and hence may be said to get these elements in part from the atmosphere, or air.

We know also that only a few plants, notably the legumes, are able to utilize free nitrogen in making their growth. From the carbon dioxide in the air, although it occurs in only very small quantity, about three or four parts in 10,000, except of course in the soil air, and in the air over fields where organic matter is undergoing decay, the plant is believed to obtain all its carbon, the oxygen of the carbon dioxide being returned to the air, for the most part, if not entirely. We do not know the function of the argon.

During thunderstorms some of the oxygen and nitrogen combine and form oxides of nitrogen, which in turn react with the water to form the nitric acid and nitrous acid, which is brought down to the ground in rains, often combined with ammonia resulting from the decomposition of organic matter containing nitrogen, and in this way plants certainly obtain some of their nitrogen. They also obtain some nitrogen and sulphur from sulphate of ammonia produced in the burning of coal. They may, and no doubt do, also obtain some other elements from the dust carried in the air.

What Plants Obtain from Air.

We may sum up the elements of plant food obtained from the air, I think, in the statement that they obtain all their carbon, and some of their hydrogen, oxygen, and nitrogen, and sulphur.

Elements taken from the soil: The ash elements—calcium, magnesium, potassium, sodium, iron, phosphorus, sulphur and silicon and manganese are for the most part obtained directly from the soil, as is also the greater part of the nitrogen. These elements must be present in the soil in sufficient abundance, and in forms which are not injurious to the plant, and which are soluble in water, or in the soil solution, in order that the plant may make a normal growth. Experiments prove that no element can replace another in plant growth, even where the elements are as much alike as sodium and potassium. The maximum yield of a crop is conditioned by the minimum present of the essential element as compared with the needs of the crop. Sodium, silicon, chlorine and manganese are usually regarded as non-essential ash ingredients, though always present in plant ash, when plants are grown under the usual conditions.

Forms of combination from which plants obtain their essential elements: With the exception of nitrogen in the growth of legumes, it may be said that plants do not take up the elements themselves, but in combination with other

elements in the form of various compounds. Carbon from carbon dioxide; hydrogen and oxygen from water; nitrogen from nitrates of sodium, calcium, magnesium, and potassium, sulphate of ammonia and other ammonia salts, amino-acids, and urea, though chiefly from nitrates and ammonia salts; sulphur from sulphates, especially calcium sulphate; phosphorus, from phosphates of calcium especially; potassium from chloride (muriates), carbonate (as in wood ashes), sulphate, nitrate, and possibly silicate; calcium, from slacked lime, ground limestone (carbonate of lime), land plaster (gypsum), phosphate of lime, and nitrate of lime; magnesium, from the carbonate, sulphate and nitrate and chloride, and possibly phosphate; iron, from oxides, carbonates, chiefly. (Organic forms of nitrogen, including "cyanamid," which are readily transformed into nitrates in the soil, are also used in large quantity, of course.) These fasts account for what we may call "natural filler." Even could we purchase the elements necessary for plant growth—were they cheap enough—they would be of no use as fertilizers. (Examples: potassium; calcium; phosphorus; nitrogen; sulphur—noting exception, sulphur, soil and manure—Lipmann. Experiments.) But there is undoubtedly rapidly coming a time when we shall use more and more concentrated sources—e. g., "Ammophos"; ammonium nitrate; possibly urea; double superphosphate, etc.

Soil Analysis.

For total plant food, including lime requirements, organic matter and essential plant food elements above enumerated. Gives absolute data for comparison of soil types. Gives potential, or reserve supply of plant food. Value and limitations. "The total amount of plant food present in the soil is surprising, in view of the fact that it is often difficult to maintain a satisfactory yield of crops." Composition of some American soils (see Hart-Tottingham, page 70). Most soils are comparatively low in total nitrogen, phosphorus and sulphur, but generally contain large reserves of potassium, calcium and magnesium and iron.

Temporary supply of plant food, measurement of amount of plant food supposedly of immediate availability to plants. Many attempts to determine by weak solvents, or by dilute solutions of strong solvents. None of these methods are general or universal guides to the manurial requirements of a soil or crop. Soil analysis are not a measure of crop needs, nor a guide to the relative amounts of fertilizers to be added.

Physical analysis of soils and their value, coupled with a knowledge of the crop-producing power of such types.

Plant Analysis.

When Liebig showed that the plant ash constituents were absolutely essential to plant growth, and not accidental as once supposed, there grew up the idea that it was only necessary to analyze the ash of the plant and add the amounts of the plant elements thus removed by an average crop, in order to maintain the production of good, average, normal crops. This was called the mineral theory of fertilization. It was proved by experiments at the Rothamsted Experiment Station in England that plants must have added nitrogen, as they could not obtain sufficient for their growth from natural sources. It has also been demonstrated that the analysis of plant ash does not furnish a safe guide

to the amounts of fertilizing elements to be added, is not a safe index to the actual needs of the crop, since the plant ash constituents taken up by the plant vary with the season, abundance of plant food available, vigor of the plant, the ability of the plant to get the different elements of plant food and no doubt other factors, including, of course, the reserve supplies of plant food in the soil.

The analysis of the whole plant is valuable as furnishing useful information as to the total amount of plant food removed by an average crop, under normal conditions, with the limitations above cited as to plant ash. Such analysis gives at least an approximation to the needs of the plant, especially when the composition of the soil is also known, but with the limitation that we are unable to determine the amount of available plant food in the soil with an exactness. Perhaps to be on the safe side, we should add the amount of ash elements plus the nitrogen indicated by the analysis of the whole plant, ignoring the plant food contained in the soil itself.

It must be apparent that neither the analysis of the soil, nor of the plant, nor of both taken together, can furnish the necessary data for the application of plant food to meet the actual needs of the plant in any given case. Hence it has been concluded that the only way of measuring crop needs for plant food is to make field experiments, which is, of course, a slow process, requiring several years in order to be able to draw really valuable conclusions.

[J. A. V.]

Crystallization of Sugar from Its Aqueous Solution.*

By Dr. H. C. Prinsen-Geerligs.

Many a time phenomena of retardation and acceleration in the crystallization of sugar have been observed as well in the practice of the sugar-house as in the scientific sugar laboratory, which up to now have remained without explanation. Every technical sugar man knows that when boiling sugar juices in the vacuum pan sugar sometimes crystallizes very rapidly, when, on other occasions, all kinds of artifices have to be employed to bring the sugar to the crystallizing point. It is also a recognized fact that in the cane sugar industry the formation of grain in the pan goes much more smoothly than in the beet sugar industry, even so that the formation of secondary, so-called "false grain" is much more to be feared there than in the sister industry. It is true that these phenomena need not be ascribed to some property of the sucrose itself, but may be brought along by the nature of the non-sugar bodies accompanying the sucrose in the syrup. We know that crystallization takes place much earlier and better in pure syrups than in impure ones, even if the proportion between sucrose and water and also the temperature and vacuum are the very same. Moreover, it may be that the more rapid crystallization in cane sugar syrups is a consequence of the different reaction,

* Louisiana Planter, Vol. LXIV, Jan. 10, 1920.

which usually is alkaline in beet sugar juices and neutral or acid in those of the cane.

But apart from the influence of the non-sugar there are cases in which, under apparently just equal circumstances, sucrose at one time crystallizes rapidly from its pure aqueous solution, while in other cases it appears very slowly in crystalline form, while as yet no reason has been detected to explain these facts.

We found in our many experiments on crystallization of sucrose from genuine and artificial molasses that sugar crystallizes much more rapidly in case the solution had been heated to a relatively low temperature and during a short time than when the mixture had been heated to higher temperatures or during a longer period, and we attributed to that property of sugar the fact that in well-equipped sugar houses, with their rapid working up of the juice at low temperature in the vacuum apparatus, crystallization of sugar takes place much easier than in laboratory experiments.

Recent experiments by "Van der Linden," published in Archief voor de Suiker Industrie in Nederlandsch Indie, 1919, 1517, stated that a molasses which, on cooling, separated a great deal of minute sugar crystals, failed to do so when after re-dissolving these again by heat the same molasses was cooled down a second time in exactly the same way.

We see from these instances that, although of course the non-sugar, present along with the sucrose in the liquid, exerts its influence on the rapidity with which the sugar crystallizes out, yet besides there exist factors which have also an influence of their own on the rapidity of crystallization of sucrose, the nature of which is still unknown to us.

In Chemisch Weekblad, 1919, page 1210, Van Ginneken published an article on the crystallization of sucrose from supersaturated solutions in which, among others, the subject considered here has been thoroughly ventilated and in which the experiments are being extensively discussed. Every one of these experiments are made with mixtures of pure sucrose and pure water, thereby excluding all influence of non-sugars and only allowing circumstances of temperature, concentration, time and intensity of movement of the solutions to enter into account.

We know that the study of crystallization of sucrose from its aqueous solution is rather difficult because of the viscosity of the syrups and the property of sucrose to form very easily supersaturated solutions, which sometimes take considerable time to come down to their permanent state of sugar content, and that is why these phenomena offer such great trouble to be examined properly.

Van Ginnken went to work as follows: Portions of 12 to 13 grammes of refined sugar were carefully weighed into test tubes of 18-20 millimeters diameter and 156 millimeters length; according to the concentration to be studied. Quantities of 2-3 grammes of water were added and the tube sealed by the blastpipe, thereby leaving a length of tube of about 130 millimeters. The tube was fixed to the perpendicularly horizontal axle of a stirrer moving in a heated oil bath to which it was attached in such a way that during the movement of the axle the contents constantly flowed from one side of the tube to the other one, thereby insuring steady and full homogeneity. The temperature of the oil bath was kept constant usually at 110 degrees C. and sometimes at 130 degrees or 135 degrees C., and the tube remained exactly at these temperatures during the

time necessary to occasion the sugar to be dissolved, which time was in most cases fixed at 30 minutes. After that period the tube was rapidly removed from the oil bath and transferred to a water-thermostat, which was the exact copy of the oil-bath and in which the temperature and the number of revolutions of the stirrer were kept constant during the whole duration of the crystallization experiment. The temperature of the water bath was kept at 80 degrees C., and it remained constant with fluctuations of no more than 0.2 degree to either side. This method of operating guaranteed solutions of an absolutely certain constitution and of a constant degree of supersaturation, cooled down and kept in a constant movement at a constant temperature with a rather satisfactory degree of constancy in the intensity of movement during crystallization.

The tubes were observed during their cooling time and the moment of apparition of the first crystal was noted, the stirring at the temperature, chosen for the experiment, continued and the moment was noted again when, by ocular inspection, the contents of the tube might be considered to have reached their maximum crystallization.

A few figures intended to give some notion of the time required may follow here: If a mixture of 84½ per cent of sucrose and 15½ per cent of water is heated in the sealed tube for 30 minutes in the oil-bath at 110 degrees C. and then transferred to the water-bath of 80 degrees C. and revolved there 33 to 35 times per minute the first crystal will probably appear after three-quarters of an hour, but it may also be that it will be ten hours before the first crystal is visible. The former case, however, is the most common one and the retardations will be considered later on.

The experiments by Van Ginneken lead to the following conclusions:

1. It is possible to state by the above-mentioned method the inclination of the formation of the first crystal and next in a somewhat approximative way the rapidity of crystallization after the formation of the first crystal.

2. The time necessary for the formation of the first crystal is much more than that required for the next ones.

3. Previous history of the solution and, in some cases, even that of the solid sugar has an influence on the inclination of formation of crystals.

In the first place series of experiments were made in order to ascertain the rapidity of formation of first crystals in sugar solutions of varying concentration at 80 degrees C., and though, as we mentioned before, the individual results do not show a fine accordance, it was proved by the majority of experiments that the most favorable concentration for the formation of crystals at 80 degrees C. is found between 83½ and 84½ per cent of sugar, or just as has been advocated by Claassen from his practical experiments as the optimum concentration of syrup to start graining in the vacuum pan. After crystals have been once formed, the further ones appear at the same temperature and concentration with much greater rapidity. If, therefore, the pan-boiler has formed his crystals in the syrup in the pan, he will see them increase in number, in case he keeps concentration and temperature at the same level as before. This has to be taken into consideration in practical working, for, as soon as one has the necessary amount of small crystals in the liquid, it will be necessary to stop the formation of new

ones so that a dilution of the syrup in the pan may not only be harmless, but even desirable.

It will be necessary to prevent formation of secondary crystals after the primary ones are present in their useful number, which have to grow in order to form a proper massecuite, and, therefore, it will be very useful to keep the syrup after the graining at such a concentration that formation of new crystals is as difficult and slow as possible. The experiments showed that under 80 per cent of sugar the inclination of formation of new crystals is so small that it may be considered as extinct. Over 81 per cent the inclination is higher and formation of secondary grain is possible under the circumstances prevailing in practical work. As, however, it is not feasible to keep concentration during boiling so low as 81 per cent, one is obliged to use higher concentrations, and that is why in sugar-house work circumstances will never be so that formation of secondary grain could be rendered absolutely impossible.

It is further the question why the first crystal is formed so much more slowly than the next ones, and in order to explain this fact Van Ginneken considers two possibilities. The first one is the autokatalytic action of already formed crystals on sucrose molecules in their vicinity, and the other the formation of large complexes of sugar molecules which have been driven apart by the heating to 110 degrees C. and now are apt to combine again at the lower temperature until they condense into crystals. This process will take some time, and then it is very obvious that soon after a few complexes have become so far condensed as to build crystals, others are very near that point and consolidate very soon afterwards.

Van Ginneken believes the two causes to coincide and the katalytic one to be the leading one.

Under autokatalytic action he understands a kind of action of a sugar crystal on still dissolved molecules which by that action are encited to form another crystal, which in its turn exerts that action on other molecules, as long as all the sucrose, existing in supersaturated state, has been combined in the crystallized form. If once a crystal is present, the others will arise very soon, and it resulted from those experiments in which on purpose the dissolution of the sugar in the oil-bath was conducted in such a way as to leave one or two crystals undissolved, the formation of further crystals in the water-bath occurred much earlier than in the ordinary cases, when all of the sugar had been dissolved, leaving no crystal to start the action.

A second proof for the katalytic action is, according to Van Ginneken, the fact that sometimes the first crystal delays its apparition during a very long time, but that notwithstanding this, the end of the total crystallization is reached after the normal time. It is difficult to believe that in such a case hours are needed to form the first crystal by condensation from smaller complexes, but that suddenly after the first visible condensation all the other complexes join to form crystals at once.

But, anyhow, this possibility may not be excluded totally, for it is not to be denied that in every case the breaking up of large complexes into smaller ones and the reformation of these units into larger and larger ones which at last form crystals on cooling must exert its influence. If not, the fact, already mentioned

in the beginning of this paper could not be explained, viz: that the previous history of the solution and even of the solid sugar plays an important part in the rapidity of crystallization of sugar from its aqueous solutions.

A great series of experiments showed Van Ginneken that heating of the solution in the oil-bath to 130 degrees C. retarded the formation of the first grain considerably over heating to 110 degrees C. and that, notwithstanding the fact that no decomposition of sugar could have been made responsible for this phenomenon.

If the contents of a same tube were made to crystallize repeatedly, after being re-dissolved again in the way indicated, the formation of the first grain became slower every time. Further, it was observed that in such cases re-dissolution became slower and slower too, while one might be apt to believe that the repeated crystallization could render that formation easier.

Finally, the previous history of the sugar itself appears to be of some importance. Van Ginneken made a great many experiments with pure refined sugar from the refinery, but wanted to repeat these with pure sucrose. To that end he precipitated a concentrated watery solution of refined sugar with alcohol, washed the fine crystals, thrown down, with alcohol and ether, evaporated the etheral fluids and used the dry, pure sucrose in his experiments. He found that the formation of the first crystals took much longer time than in his experiments with the refined sugar, for which he could not account.

He mixed minute portions of impurities such as might be present in refined sugar with the pure sucrose in order to see if these were the reason of a better crystallization, but without avail. On the other hand, he ground refined sugar to a fine powder and used that in order to know if, perhaps, the fine crystalline state had exerted some influence, but the finer refined sugar did just as the coarse one and not as the pure precipitated preparation.

We are led to assume that the pure sucrose is precipitated by the alcohol in a configuration deviating from the one in which it crystallizes from its aqueous solutions. On using the same pure sucrose for further experiments after it had stayed during a few months in a bottle, the behavior in the tubes was identical with that of the refined sugar, so that perhaps the deviating configuration has become normal after some time.

At all events, the experiments show distinctly that the previous history, both of the solution and of the solid sugar, have an influence on the inclination of the sucrose to combine into crystals, and it is very probable that the sometimes rather large differences in the results of two experiments made in apparently exactly the same way, may be traced back to some factor in the previous history of the substance used, of which we have as yet no knowledge

It is very important for the proper working of the boiling process in the vacuum pan if these factors could be ascertained and investigated, and in that case we believe that the method used by Van Ginneken may shed new light on the subject, so that continuation and repetition of these experiments will be of a great value for our industry. [W. R. M.]

Sugar Cane Culture in South Africa.*

Climate for Cane.

Sugar cane is essentially a tropical plant, and though it will grow in the Midlands of Natal for fodder purposes, it fails as a sugar producer. Being tropical in its natural habitat, regions planted with cane must be frost free. They must also be moist, and with the moisture there must be heat.

The climate of Zululand is more suited for cane culture than the climate of Natal, due to its greater humidity and heat, whilst the Natal coast belt enjoys a rainfall of 35 inches to 40 inches on an average. The best cane-growing parts of Zululand and Portuguese East Africa have an annual precipitation of 60 inches or over. This rain falls chiefly in the summer months, hence the greatest growth of cane takes place during the summer. The advent of the dry winter months sets a period to the rapid growth of the cane, a factor which is of great service to the miller. The drier months cause the cane to "ripen"; the moisture in the plant is greatly reduced, and thus the sap has a higher percentage of sugar in the juice. The dry weather is also favorable for harvesting operations, as it allows of the trash being removed by burning—an easy way for the planter, but not the best.

The dry weather generally commences in April, and may extend until August or September. These are the months when the crushing is done, though latterly, due to labor trouble, etc., the mills have been running almost the whole year round, leaving off only for a space of time sufficient to overhaul the plant. Natal's precipitation is not sufficient to mature a crop of cane in twelve months, nor is it tropical enough to do this. Zululand is better in this respect. There, cane will be ready for cutting eighteen months after planting.

Soil Requirements.

A crop which is capable of growing to the amount of 60 tons per acre every two years demands soil which is very well adapted for plant growth. The factors required for growth are three in chief: (1) Moisture, (2) plant food, (3) heat. To these should be added a favorable mechanical condition of the soil. The soils in the cane are two chief types, with several variations in different directions from the types. The two types may be contrasted as follows:

(1) *Red Hillside Soil.* (a) The hill soils are free workers; (b) Never become water-logged; (c) Are very easily penetrated by cane roots; (d) Are not so rich in plant food; (e) Dry out sooner in dry weather, but can be worked even when dry; (f) Are the earlier soils, from which cane should be harvested the first; (g) Have the better mechanical conditions; (h) Are not sour.

(2) *Black Vlei Soil.* (a) The vlei soils are more difficult to work; (b) Tend to become water-logged in summer; (c) Cane roots penetrate less deeply; (d) Are richer in plant food; (e) Dry out more slowly, but when dried cannot be cultivated; (f) Cane may stand longer on these soils without harm resulting;

* E. R. Gessner, in The South African Sugar Journal, Sept., 1919.

(g) Have the poorer mechanical condition; (h) Are usually sour.

From the above, it is evident that considerable differences exist, and both types of soil will most likely occur on any holding. In addition to these two types, mention should be made of a third type found along river banks and flats, soils liable to be flooded at times of heavy rain, but excellent producers when climatic conditions are favorable.

When a planter is starting operations upon new land, he will probably start with the hillside type, as being the more readily brought into condition for planting. Far more experience is required to handle heavy vlei soil than is necessary with hillside lands.

Hillside or vlei land may both be covered with indigenous trees or bush, or be mostly in grass. In the latter case the operations are the easier, and will be considered first.

Plowing and Ridging.

(1) If the grass is not too long and rank to be plowed under, it should be so treated. If plowing would leave considerable quantities of grass uncovered, then the material should be burnt off in order to enable a thorough preparation of the soil before planting.

The best plows for breaking up new lands of this description are mould-board plows with disc coulters, oblique shares and long shallow convex mould-boards. Such a plow will roll over the furrow slice completely, but will not pulverize it to any extent.

Land which is full of grass roots of this description should be allowed to lie some time after plowing, if possible, in order that decay of roots may crumble the soil and facilitate further operations. In some cases, where the planter must push ahead with the soil preparation work as fast as possible, time cannot be spared for this mellowing action to take place.

After plowing, the soil should be harrowed across the furrows with a cut-away disc or ordinary disc harrow, giving two or three harrowings in the same place if necessary. A second plowing across the furrows of the first plowing should pulverize the soil fairly well, so that when harrowed with zig-zag harrows it is in fairly good tilth and ready to be ridged and planted. The furrows or drills in which the cane is planted should be about 5 feet apart and 6 inches deep. If the land has been brought into good tilth these furrows can be made with a double mould-board plow. If the tilth is poor, completion of furrows made with the double mould-board plow must be done with hoes, adding considerably to the expense of establishing the crop. As the initial preparation of the soil is required for at least eight to ten years, it is imperative that it be thorough and not shirked, or poor crops will result for the whole of that time.

(2) Where there are trees to be cut down, the initial expense is greater, and these will retard the plowing, harrowing, etc., of the land. Under such conditions, when the trimmings from these trees have been burnt, the soil is ridged with hoes as well as possible, leaving stumps to decay in the ground. The after-working of the cane on land which has grown bush is also more expensive, as it is not possible to use mule or ox labor in the cultivations. All cultivations require to be done by hand.

(3) The third type of land is that which is carrying heavy bush, wild banana, etc. This land grows good crops of cane when cleared, but the expenses incurred in clearing are very heavy, and such land will be left until the last. This is land which is on the margin of cultivation. It is estimated that the cost of clearing such soil, grubbing out wild banana and other stumps to bring the land into condition for plowing will cost £10 per acre. Further plowings, harrowings, drilling, seed cane, planting, weeding and earthing up will cost £4 10s. per acre, making a total cost to establish plant cane under these conditions £14 10s. per acre. This is a very heavy initial expense, and requires large returns for a number of years to compensate the planter for the heavy cost involved.

The heaviest item in this class of land is the clearing. This may be somewhat reduced by the use of "Forest Devils," implements for stump extraction. Six strong natives working one of these will deal with anything up to half an acre per day. With the large stumps, the tap root should be eased by means of choppers, and then the stump can be extracted, as the side roots do not give much trouble. This implement is also of use on cane fields where stumps were left in and planting done by means of making furrows with hoes. After the plant crop is harvested, the old stumps can readily be removed. Such areas can then be cultivated by horses, mules or oxen, with cultivators or pony plows for inter-row work. Stump extraction with dynamite has been tried on the sandy soils of the coast but without success.

Where much bush has been removed, the plowings are frequently dispensed with, ridging being done with hoes. In making the furrows or drills on such lands, the earth should all be placed at one side of the drill, and when the cane is being planted it should be covered with soil taken from the other side not worked. By carrying out this method, weed growth is checked considerably, and this enables the young cane shoots to get well ahead of the weed growth. The young shoots are more easily seen, and are not so likely to be damaged during cleaning operations.

The cost of establishing cane on ordinary grass lands with a small amount of bush is about as follows: Plowing, 10s. per acre; harrowing, 1s. per acre; grubbing out roots, 15s. per acre (burning grass undergrowth, etc.); drilling out, 15s. per acre; cost of plant cane, £1 per acre; planting and covering, 5s. per acre; first weeding, 10s. per acre; second weeding, 7s. 6d. per acre; third weeding and earthing up, 12s. 6d. per acre—making a total cost of £4 16s. per acre. Where more than one plowing and harrowing has to be given, the cost of establishing the cane will be higher.

Planting.

In planting, the furrows or drills are usually spaced about 5 feet apart, are 9 inches wide and 6 inches deep. A double line of cane is laid along the bottom of the furrow and covered with about 2 inches of soil.

Experiments have been carried out at the Government Experiment Station at Winklespruit with plant cane in order to find out the best age, etc., of plant cane for its purpose. The experiments have been duplicated at different times,

and the results secured have shown that canes twelve months old are the best for planting.

The portion of the cane which is planted is the stem, and, as with other stems, more vigor is shown in the younger parts than in the harder parts. In picking cane for planting, care should be exercised, and only the strongest, healthiest and vigorous stools used. There is too little attention paid at the present time to the selection of canes for planting purposes. The age of the crop from which the plant cane is taken should be from twelve to fifteen months, and the crop should be either the first or second crop after planting, i. e., plant cane or first ratoon. The cane should be trashed before planting, so that imperfections, poor growth, disease and insect trouble may be observed and eliminated. Cane of the age indicated gives a good stand of young cane and an earlier growth, with the result that less labor is required for weeding and keeping the crop clean, due to the greater vigor of the crop.

It has also been noticed that a better growth is secured from the middle and tip portions of the canes than from the butts, and this in both the Uba, the standard variety, and the Agaul, a recent introduction from India.

Cultivation.

Should the plowing and planting have been carried out in a thorough manner, the crop will be in a position to start well, providing beneficial rains are experienced. The cultivation given in the preparation of the land for the crop is not sufficient, however, to ensure a good crop without further attention. In tropical areas, weed growth is so luxuriant and so rapid that much work has to be bestowed upon the crop to keep it clean. In the drills where the cane is planted there should not be much weed growth, but between the rows there will be plenty of weeds. In the hoeings and cultivations which are given, the soil from between the rows is gradually worked up to the cane as it grows. The first weeding is generally done by hand, the second one by cultivators, and with the third one the canes are banked up by means of a small single-furrow pony plow, plowing the furrow towards the row of cane. For cultivation work, mules are the most suitable. Oxen are somewhat destructive to young cane, and are slower than mules. Mules, again, are hardier than horses, can be better immunized against horse sickness, and are less costly to keep, thriving on poorer fare and under worse conditions than horses will do.

One point worthy of note is that, where soils are somewhat shallow and where deep-rooting varieties are used, a single-line scarifier may be run along the bottom of the furrow before planting takes place. This tends to increase the soil space and its water-holding capacity, and to favor the deep penetration of the roots.

Planting is generally done from September until the end of the year, but the operation is dependent to a considerable extent upon the rainfall.

Varieties of Cane.

The variety of cane which is most largely grown in Natal and Zululand is the "Uba." This cane has proved itself to be the best adapted to local conditions for a very considerable time. The varieties which were grown in Natal in the early

days of the sugar industry have been superseded, and many introductions since the Uba have been discarded. It is evident that the Uba variety will run the risk of "growing itself out" unless greater care is bestowed upon the selection of the canes for planting. With care bestowed upon the selection of the cane for planting for some time, the average of the last season's crop at the Winklespruit Station was 35 tons per acre, no fertilizer being applied.

The Uba cane is a somewhat thin cane, yellowish to yellow-green in color, and with internodes which attain a length of 6 inches or more in well-grown canes. Where the conditions for growth have been unfavorable, the internode length is much shortened, as they also are when the cane is nearing maturity. The Uba is a hardy cane, and, from the miller's viewpoint, is possessed of several undesirable characters, in that it is high in fiber content and requires more power to crush and handle than the softer varieties. It is possessed of splendid ratooning powers, and this is a factor which has chiefly to do with the large area under this variety. Where conditions are favorable, four or more ratoon crops may be secured from the one planting, so that the crop occupies the soil for ten years or more before replanting is necessary. It is thus evident that a thorough initial preparation of the soil is much to be desired. The dead leaves of this variety remain adherent to the stalk, or, in other words, the cane does not trash itself. This necessitates trashing before harvesting, or, as is often done, though against scientific principles, burning.

It is a deep-rooting cane, readily adaptable to varying conditions of soil, for it is to be seen growing upon the blackest of alluvial loams to the reddest of shallow and dry hillside soils. It is hardy and resistant to both fungal and insect attack. In Natal and Zululand, so far as is known to the writer, fertile seed has never been produced by this variety. The cane arrows or flowers fairly frequently in some seasons, and more so on the red sandy loams than on the richer soils. This would seem to be in accord with the general law that, where the conditions are most favorable, vegetative propagation will keep the plant going, but that as soon as unfavorable conditions appear an endeavor is made to produce seed. It is only from seedlings that the combined characters of Uba, along with those of other canes, can be obtained, and the crossing of different kinds must, therefore, be carried out in other countries.

The Agaul cane, as already noted, is a fairly recent introduction from India, and greatly resembles the Uba cane in every respect. It is, however, a more vigorous cane, surpassing the Uba in rapidity and luxuriance.

Soft Canes.

These canes are much thicker than the Uba, and the individual canes several times heavier than the individual Uba canes. They are not adapted for growth upon hill soils, but find conditions best suited for their growth in the richer, heavier, alluvial and vlei lands. Generally speaking, they compare badly with the Uba. They are strictly limited to certain areas; they are shallow rooters, poor ratooners, more liable to be attacked by fungal diseases and insect pests, and suffer more from winds. It is no uncommon thing to see soft canes so blown and twisted about that one is unable to distinguish which way the lines run. They likewise suffer very much during droughty spells. They yield heavier returns

for the first season than the Uba, but after one season's growth they ratoon badly, and subsequent growths cannot compare with the ratoon crops of Uba. They are thus seldom grown in this country.

Varieties of soft canes which have been tried at the Winklespruit Experiment Station are: Six varieties from Demerara, ten varieties from India, four varieties from Antigua, two varieties from Queensland, three varieties from Egypt; other varieties: Horne, Honolulu, Rose Bamboo, Green Natal and Louisier have also been tried. Latterly, several varieties of cane introduced by the Natal Sugar Association from the Argentine have been planted at Winklespruit, and are being tested alongside the standard variety Uba. At the time of writing, these canes are growing quite nicely, and appear promising. In other parts of the world the soft canes are largely grown, but there planting is usual every year. Powers of ratooning are not of great value where annual planting is the practice.

Harvesting.

The crop from Uba plant cane generally takes about 22 months from the date of planting to mature for crushing purposes. Ratoon crops are ready for crushing at about 20 months after the previous crop has been removed. Both of these periods are liable to alteration, due to the great influence exercised by the variable weather conditions. The soft canes mature in about 12 months, but the returns from a plant cane crop are only about the same as from the Uba. The soft varieties demand greater heat and moisture and richer lands than the Uba, and, therefore, cannot oust it from the position which it occupies in this country.

The actual cutting of the cane is done by hand, after the trash has been removed either by hand or by burning. The former method is advocated as yielding back to the soil the organic matter which it so much needs.

Native and Indian laborers are employed for the cutting, which is done with large cane knives. It is important to see that the cane is cut low, almost into the ground and as near the stool as possible. The root end of the cane is richer in sugar, and if stumps are left, these tend to decay, and the disease may spread to the living stems. The vigor of the ratoons also appears greater when close cutting is practised. Four good workers will cut and load six tons of cane in a day. Cane should be forwarded as soon as possible to the mill after cutting, lest undesirable fermentations take place in it. After cutting, the cane is forwarded to the mill either by wagons or by small trucks on tram lines.

The latter are the better and easier way, though the initial outlay is larger. The loading of the cane into wagons and off-loading and loading into railway trucks is a laborious and costly operation. When the density of the juice is at its highest, it requires about eight tons of Uba cane to yield one ton of sugar, but frequently the amount required is considerably higher than this, especially in wet seasons.

Full reports dealing with the effect of artificial manures upon sugar cane are to be found in Vol. III, "Cedara Memoirs," obtainable from the School of Agriculture, Cedara, and also in a bulletin on "The Sugar Industry," by Mr. C. Williams, B. Sc., Chemist to the School of Agriculture, Cedara.

Future Development.

The production of sugar in South Africa has now reached that stage when it will be necessary for it to enter into competition with sugars grown in other parts of the world, and, this being the case, it behooves the producer to examine the method of production in order to ascertain if the system in vogue is the cheapest and best.

The price of sugar on the world's market will not fluctuate very much, and though there is a tendency for civilized nations to consume more sugar, this increase probably hardly keeps pace with the increased areas put under sugar cane. The present tendency is for wages to rise, so that any method of cheapening production is likely to find favor in the eyes of the producer.

On large tracts of land suited for steam plowing, etc., this form of power will be utilized. On smaller areas motor power may yet find its place. The beginner, however, will probably be dependent upon oxen or mules. Lands must be so laid out that practically all the cultivation can be done by oxen or mule labor. Hand-weeding must be dispensed with. On land where there is no trash to interfere with cultivators, these should be used as far as possible.

Selection of higher yielding stools should also be practised, and high-yielding stools should be tested out individually, so that the best producing strain may be secured. In these ways, by lowered cost of production and increased return, the planter should be able to earn a good living from sugar production.

[J. A. V.]

Flies.

By Donald S. Bowman, *Industrial Service Bureau, H. S. P. A.*

The common flies found in our plantation villages are responsible for the spread and development of typhoid fever in the majority of cases. That the human typhoid carrier has much to do with the spread of the disease from plantation to plantation has been demonstrated many times by sanitarians. The privy vault is the favorite breeding place for the fly; there he harbors until the vault is used by a typhoid carrier. His flight in general is from the privy to the food supply, which he contaminates.

Years ago on one sugar estate on Hawaii typhoid was prevalent in a village near the sea coast. The open privy was in use, and flies multiplied rapidly. Acting upon the advice of a sanitarian who determined that flies were responsible for the spread of the disease, a system of water-flushed toilets were installed, and in a short time typhoid was eliminated and there has been no recurrence of the epidemic. Other instances of a like nature might be cited as having occurred throughout the Islands and in many communities on the mainland. For

our health protection the fly must be fought; and we know of no better health insurance than the intelligent expenditure of money on sanitary measures that will rid the villages of fly-breeding nuisances.

"The Transmission of Disease by Flies," by Ernest A. Sweet, of the U. S. Public Health Service, is here reprinted.

The Transmission of Disease by Flies.*

By Ernest A. Sweet.†

(*Contributed by the Industrial Service Bureau, H. S. P. A.*)

Insects play a definite rôle in the transmission of disease, a fact which has been conclusively demonstrated over and over again. Many of the most serious ills of man are conveyed from person to person through the medium of mosquitoes, flies, lice, ticks, and other forms of vermin. How the transmission of disease is effected, the particular insects acting as carriers, and the means of combating such pests have all become matters with which the public is concerned.

Of the natural enemies of man, the fly unquestionably takes precedence over all others. Possibly there may be some tendency to accord to the mosquito this unique position, but if a careful summary be made of the activities of both flies and mosquitoes, the former, it is believed, will necessarily be rated as the more harmful and dangerous. Only recently has it been possible to convict this insect of the many crimes and misdemeanors of which it is guilty. We now know that flies, instead of being harmless insects, of moment only when they invade our food supplies, are in reality highly dangerous, and that a single fly may be responsible for the development of typhoid fever or other illness of a serious nature.

Kinds of Flies.

There are many kinds of flies, not all of which have the same structure, habits, or methods of reproduction. In a general way, however, the families resemble one another, and while the following description applies principally to house flies, with slight modifications it is applicable to other varieties as well.

The most common and widely distributed of all flies is the house fly. This insect is ordinarily present in all parts of the world and lives in practically any climate adapted to man. Nine-tenths of the flies found within or near dwellings belong to this group, although a number of other species so closely resemble house flies in appearance that differentiation may be impossible by other than experts. The favorite haunt of the house fly is the dwelling of man, and it is seldom found away from human habitations.

The bluebottle, or blow fly, is a second familiar species, owing to the characteristic and disturbing noise made in its flight. It has a strong liking for the

* U. S. Public Health Service, Supplement No. 29 to the Public Health Report.
† Passed Assistant Surgeon, United States Public Health Service.

exposed surfaces of fresh meat and fruits, the former seemingly having a powerful attraction for the insect, but it is not averse to entering houses.

Bearing a strong resemblance to the bluebottle fly is the greenbottle fly, which is slightly smaller and metallic green in color. It is commonly found near putrefying flesh, such as dead animals, excreta, and similar filth. A member of this family often breeds in the excrement on the backs of sheep, the larvae or maggots developing and feeding thereon, resulting in a serious pest to flockowners. When the larvae mature in either filth or flesh they are especially voracious and consume a large part of the substance on which they are developing. The fact that insects of this family alternate between human excreta and food products

The House Fly.

renders them especially dangerous, although their number is usually limited and they are seldom satisfied to remain within doors.

One of the most important species is the stable fly, or, as it is sometimes called, the "biting stable fly." It is less often found in filth than the other varieties, but owing to the fact that it is a blood-sucking fly, opportunity for the direct inoculation of persons and animals with the organisms of disease is presented. It is this insect which has been incriminated in the spread of anthrax. The stable fly is about the size of the common house fly and resembles it in appearance, being gray in color and somewhat more stoutly built. Its proboscis, however, is of an entirely different character, as campers and others can testify, being arranged for penetrating and sucking. It frequently torments horses and cattle and may even cause detriment to stock through its activities. The insect is widely distributed. Closely allied to the stable fly is an African species known as the tsetse-fly, which is responsible for the spread of sleeping sickness, a fatal infection found in certain regions of the African Continent.

The "lesser house fly" is the name given to a species which, next to the house fly, is the most common indoor resident. Probably everyone has observed the useless and apparently aimless, jerky flight of this insect beneath some suspended article, such as a chandelier. This fly is an early visitor, usually being found before the common house fly is present in large numbers. Its breeding habits are the same as those of the house fly, but as it feeds less diligently and seldom alights, it is somewhat less objectionable. It strongly resembles the house fly, but is slightly smaller and more slender, being, perhaps, better adapted to flight. The larval form of this fly is easily distinguished from that of the common house fly, as it is covered with spines.

In addition to the species enumerated, many other bloodsucking and non-bloodsucking varieties are of interest. The cheese fly deposits its eggs in cheese or fatty material, producing the so-called cheese skippers. The dung and the yellow dung flies and the latrine fly are so named because they develop in the excrement of animals or man. The fruit fly, a much smaller species than any of those mentioned, hovers about fruit juices, cider barrels, and like situations, being often found in the dregs of wine. None of these species, however, is as important as the common house fly.

Structure.

The parts of the fly are the head, thorax, and abdomen. The head is connected with the thorax by a narrow neck which permits of rather wide movement. The greater part of the head is occupied by the eyes, some several thousand in number, described as compound. Between the compound eyes and near the top of the head is a triangular arrangement of three simple eyes. The upper two are much farther apart in the female than in the male, thus serving to easily differentiate the sexes. In spite of the arrangement of the eyes and the great mobility of the head, it is not believed that the vision of flies is especially acute, although the range of vision is wide. The sense of smell, however, is highly developed.

The proboscis protruding from the under and back part of the head is the most interesting part of the fly. When the insect is at rest, the proboscis is

folded against the head, but upon alighting it is protruded through the mechanical action of certain air sacs. Capping the end of the proboscis are two oval projections or lobes forming an opening leading into the mouth. The oral lobes in the house fly entirely prevent penetration of the skin by the proboscis, therefore this particular species is in no sense a biting fly. Biting invariably constitutes positive proof that the insect is not a house fly, however much it may resemble that species. On the under and inner side of the oral lobes are grooved channels which lead into the mouth. When these channel-like surfaces are placed in contact with liquids, suction is performed by the pharynx and the substance is drawn into the œsophagus, to be continued through the narrow neck into the thorax. If the food is solid it must first be dissolved through the action of saliva secreted by the salivary glands or reduced to very minute particles.

The greater part of the thorax is occupied by the muscles used in flying, these being placed above the stomach. Connecting with the œsophagus after it passes into the chest is a small duct leading to a dilatation within the abdomen known as the crop. From this receptacle feed is frequently regurgitated, appearing at the mouth parts in the form of small globules, to be again devoured at the insect's leisure. It is this habit of regurgitation, or vomiting, which renders flies extremely objectionable from a sanitary standpoint, particularly as the stomach contents are obtained in most instances from filth and garbage.

Several segments make up the abdomen or after portion of the body, the number varying with the sex and species. The last four segments in the female form the ovipositor. Owing to its telescopic character, this organ may be partially withdrawn within the abdomen or extended when in the act of depositing the eggs. In this manner eggs are laid in cracks and crevices or deposited beneath the surface of filth, thus affording excellent harborage for the larvae. During the breeding season, which continues throughout the summer months, the abdominal cavity of the female is densely packed with eggs.

The wings are attached to the thorax and are characterized by dark lines or veins extending through the wing membrane, the markings varying with the different species. There are three pairs of legs, all rather thickly covered with hair. Both the legs and wings are admirably adapted to the mechanical transference of substances with which they come in contact. It is this interchange of material, derived in many instances from polluted and filthy sources, which constantly exposes man to the danger of disease.

Reproduction.

Flies are extremely prolific. The stages in the life cycle occupy at the most but a few days, and sexual maturity is reached within three or four days from the date of birth. As the eggs deposited by the female usually number a hundred or more, an enormous increase in the fly population is possible within a short period of time. Like many other insects, flies pass through several developmental stages, the immature forms differing radically from the adult. There are four stages in the developmental cycle, namely, the egg, then the larva or maggot period, next the pupa, chrysalis or resting stage, and finally the adult fly. A thorough understanding of each of these stages is essential for a proper appreciation of the rôle flies play in disease transmission.

Nearly all flies breed in organic filth. A favorite medium is horse manure, but decaying vegetables, fermenting kitchen refuse, human excreta, and putrefying animal matter offer sites which are nearly as well adapted to the conditions necessary for propagation. The barn manure pile may be the place of origin of thousands of flies, the unprotected and unscreened privy serves as an excellent nidus for their growth, while fermenting foodstuffs and other waste food products scattered about the yard may also assist in their propagation. But three conditions are necessary for fly propagation in filth of this character, namely, proper temperature, moisture, and food supply. The warm manure pile and the decaying and fermenting garbage heap admirably fulfill these conditions. The swarm of flies invariably seen about places of this character during the summer season is an indication that not only feeding but actual propagation is in process.

Mass of Larvae in stable manure.

The breeding season varies with the climate, usually beginning during May in the North, but more often in early April or March in the South; propagation continues until late September. The fly population is usually greatest during August and September, after which it very rapidly diminishes.

The eggs of the common house fly are smooth, white, glistening bodies about a twentieth of an inch in length, oval in shape and slightly broader at one extremity than the other. They are usually found in irregularly massed batches, each female depositing several such aggregations during her lifetime. The long ovipositor enables the female to deposit the eggs in crevices or beneath the surface of filth where the desiccating action of the atmosphere is less pronounced. Ordinarily a period of but 12 hours is required from the time the eggs are deposited until they are transformed into larvae, although if the temperature is not favorable, two, three, or more days may be necessary. Hatching merely consists of the splitting of one extremity of the egg sac and the emerging of the larva.

The larvae, or maggots as they are commonly known, represent the second stage in the development of the fly. They are about twice the size of the eggs but of much the same color and shape, the body being somewhat indistinctly segmented. There are no legs; nevertheless, by aid of the mouth parts and rudimentary enlargements on the under surface of the body the larvae are actively motile and may travel a considerable distance. During the course of their growth they pass through two moults, constantly feeding upon the substance in which they are contained and reaching maturity in from 3 to 6 days. The larvae exhibit a tendency to congregate in a zone just beneath the surface of the mass upon which they are developing, seldom being found directly upon the surface. After arriving at maturity they migrate or leave the substance where they commenced their growth, burrowing into the soil or even traveling a distance of

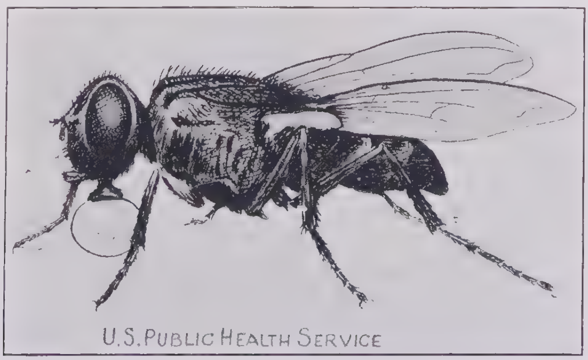
several feet over the ground. This migration must always be considered and guarded against when fly-eradicative measures are instituted.

When the fly reaches the third or chrysalis stage of its development it is known as the pupa. This period is characterized by a contraction of the body, a change to a darker color, and a disintegration of the larval parts, with a corresponding growth of the wings and other structures of the future fly. The pupal stage ordinarily continues for about three days, when the adult and fully grown fly emerges from the sac. After exposure for a short time the integument hardens, the wings dry, and the insect is ready for flight.

Under average conditions the entire cycle of development from egg to adult fly occupies a period of only from 8 to 10 days, but the time may be prolonged under unsuitable conditions of temperature or food supply to 20 days or more. When the eggs are deposited upon nonfermenting vegetable matter, the period may also be somewhat lengthened, but the instinct of the female invariably leads her to place her eggs in the most favorable locality. The important consideration is, however, the ordinary developmental period, from 8 to 10 days. Manure, filth, or garbage which has been exposed for a longer period than one week is almost sure to breed flies. The removal of such filth and manure as often as twice a week, or its proper protection, will largely prevent the breeding of these insects. The relation between the quantity of such material present and the number of flies is always direct and definite and its removal is invariably followed by a decrease in the fly population.

Habits.

In its habits the fly is probably the most objectionable insect with which man comes in contact. It not only breeds in filth, but it continues to frequent objectionable material throughout the days of its existence, leaving it only to invade the residence of man, contaminate his food, and oftentimes to spread disease.



House Fly regurgitating liquid material.

The house fly is a persistent feeder, but the feeding process itself is somewhat slow. Flies are very industrious in their search for food, even when it is right at hand, crawling over the surface thereof and evidently searching with the proboscis for more dainty morsels. On their excursions of this character

they may carry with them, particularly on the hairy parts of the legs, the organisms of infectious disease, the eggs of various parasites, and organic filth. Should they next visit our tables, this dangerous material is distributed over our food. When food so contaminated is taken into the stomach, man is directly infected and may develop any one of a number of diseases.

Another manner in which flies disseminate infection is through the regurgitation or vomiting of food. It is unpleasant to consider that insects which have but recently frequented garbage heaps, cuspidors, and manure piles may be guests at our tables, but it is all the more disgusting to consider that the very material of which they have partaken should be subsequently distributed over our own food and then received into our system. Similarly, the numerous brown excreta spots or fly specks on walls and ceilings which are the bane of every housewife prove by their very location that they should be far less the objects of hatred than those which are deposited elsewhere. The number of such vomited and fecal spots deposited by well-fed house flies may be enormous, frequently rising to a hundred or more a day.

The range of flight of house flies is ordinarily not great. They probably seldom travel more than half a mile from their breeding place unless carried by winds, and usually remain within 200 or 300 yards of their point of origin. Therefore, if flies are found in a particular neighborhood it is fair proof that they developed in the immediate vicinity. The range of flight may be ascertained by anyone who is interested in such experiments by coloring insects with aniline dyes and, following their release, recapturing them either by traps or fly paper at various distances.

Flies are attracted to houses either by the odor or presence of food. Warmth also proves seductive. In cold weather they seek shelter to hibernate, crawling into unexposed places and living for several weeks in a semidormant condition. Following the onset of warmer weather they revive and become the forbears of a numerous progeny, thus continuing the race from season to season. For this reason exterminative measures are of greatest value if begun early. It is also probable that continuance through the winter season is due to the prolongation of the egg and larval stages by the low temperature. In spite of a considerable resistance to cold which flies manifest they are at the same time quite susceptible to its influence, preferring quietude to activity when so affected. Sunlight and brightness are usually attractive, a fact familiar to every housewife.

Carriers of Disease.

Flies may transmit disease in either of two ways. The first method is by mechanical transference, whereby the insect becomes contaminated with the parasites or microorganisms of disease as a consequence of frequenting filth and places where these agents abound, thus carrying pathogenic organisms directly to food or drink partaken of by man. This is by far the most common method of conveyance. All forms of flies may act as disease carriers in this manner, but the house fly is the principal offending species owing to its prevalence and great tendency to frequent filth. As previously stated, the body of the fly, with its stiff, hairy parts, is well adapted to transference of contagion in this manner.

Experiments have been conducted to show the length of time flies may carry

the organisms of infection, but this naturally varies. If conditions are favorable, there is little doubt that bacteria may be transferred in this manner after several days. If the organisms are taken into the intestinal tract of the fly, this period may be lengthened, the feces serving as the agent of transmission and prolonging the infective stage. When it is realized that milk, which is one of the best media for the growth of bacteria, may be contaminated by flies merely through the act of feeding and that "clean flies" may even derive infection from those which have but recently visited outhouses and stables, the dangers of food contamination may be conceived.

The second method of disease transmission is by inoculation, that is the actual injection into the system by the insect of pathogenic organisms or parasites. Fortunately, disease can not be transmitted in this manner by the nonbiting flies, else our safety would be far less than at present, the bloodsucking varieties being only those which are of danger in this respect. In our country these varieties are relatively infrequent. The mode of transmission is similar to that in which malaria is conveyed by the mosquito, typhus fever by the louse, and plague by the flea. The parasites or organisms derived from the blood of the infected person are received into the stomach of the fly, where they may undergo developmental changes requiring a specified period, and are subsequently inoculated into a second individual.

Of the diseases which may be transmitted by flies, the following are worthy of consideration: Typhoid fever, diarrhea and enteritis, cholera, dysentery, paratyphoid fever, intestinal parasitic infections, sleeping sickness, surra, nagana, with a number of others where there is a dictinct possibility of transference.

Typhoid fever is the most common and important infection of man conveyed by flies. It is an acute, infectious disease of bacterial origin, contracted only by taking into the system the bacteria containing discharges of one actually ill of the infection or of some person who serves as a carrier thereof. It may be contracted through sewage-polluted drinking water, infected shellfish, or in other manner, the only requisite being the presence of the typhoid bacilli in the food or drink of man. It is essentially a disease of filth, but unless means are established for the transference of such filth to the mouths of persons the infection never develops. Flies frequently serve as the means of this transference, and are therefore in part responsible for the dissemination of the disease. In the United States alone during 1914 over 14,000 persons died from typhoid fever and ten times that number suffered from the infection, the rate being several times higher than that of many civilized countries.

Attention was called to the agency of flies in the transmission of typhoid fever during the Spanish-American War, when hundreds of our soldiers died from this altogether preventable infection. It was clearly established that the high incidence of the disease was in part due to the presence of myriads of flies which visited the unscreened and unprotected latrines, later to be accorded free access to the kitchens and dining halls of the troops, where every opportunity was available for the contamination of food. In certain instances the very chemicals used in covering discharges were found upon the bodies of the insects and occasionally upon the food itself, indicating that fecal matter was present and that infection in this manner was possible. The investigations of that time

have since been confirmed, and it is now a well-recognized fact that whenever flies have access to the discharges of man and at the same time to his food supply, disease will necessarily occur.

The conditions which prevailed during the Spanish-American War exist in thousands of American communities today. We look with horror upon the frightful and unnecessary sacrifice of lives which then ensued, yet within our very vision identical conditions prevail and we remain quite undisturbed. The unscreened and unprotected privy constitutes a grave and serious menace to the health of any community. Sooner or later it is bound to become the depository of typhoid excretions, and at that moment it becomes a hazard to every resident in the vicinity, for that very environment has created an insect host capable of disseminating the scourge to every point of the compass. It should be understood that typhoid-fever bacilli never originate in flies themselves, but are always derived from infected human dejecta. Not only are the bacilli contained in the feces of man, but in other excretions as well. Persons actually ill of typhoid excrete enormous quantities of such organisms, but these cases may actually be of less danger than others, inasmuch as in the majority of instances proper disinfection and disposal of such material is secured. Many persons, however, continue to excrete these dangerous organisms long after they are well, in some instances for years, and thus are a constant source of danger to the public. So common is this condition that at least 2 per cent of those who have recovered from the disease can be rated as typhoid-bacillus carriers. Again, walking or ambulant cases of typhoid are frequent, and in certain instances the condition goes unrecognized or is mistaken for something else, so that necessarily there is, and will continue to be, serious danger through the medium of flies from these apparently harmless persons. In unsewered districts this hazard is proportionately greater, but even in sections properly provided for in this respect the menace is never negligible if flies exist.

Flies which have access to outhouses and to tables may contaminate any variety of food. Milk is frequently subject to infection, and numerous epidemics of typhoid with resulting deaths have been traced directly to dairies unprovided with proper facilities for the disposal of excreta. Given a typhoid carrier and the presence of flies, together with an unprotected privy vault, and the stage is completely set for the development of the drama of disease. Food purchased in fly-ridden markets may likewise be a source of contamination, and if eaten uncooked may lead directly to illness. Cooked food of whatever nature may be contaminated subsequent to the cooking, constituting a serious menace to health. Irrespective, then, of the precautions we exercise as individuals, we are all more or less exposed to the infection of typhoid fever through common sources. Further, as a result of the laxity of others, even when we ourselves may have exercised every precaution necessary to prevent the development of flies, our lives are frequently endangered.

A second infection, and one analogous to typhoid, frequently conveyed by flies, is summer diarrhea. This is more particularly a disease of children, but adults are also susceptible. Annually in the United States 70,000 infants under 2 years of age die from diarrhea and enteritis, the infectious nature of which has now been definitely determined. Bacteria of various varieties are known

to be responsible for the disease. The sources of infection are much the same as in typhoid, the causative organisms reaching the alimentary tract as a result of uncleanliness, infected food, and very possibly by contamination of hands or food through the activities of flies. The evidence against the fly as a conveyor of the infection is largely circumstantial, yet so conclusive is it that no one would fail to place the responsibility upon this insect.

First, the disease exists in the summer season, when flies are known to be prevalent. Its incidence varies directly with the incidence of flies, the summer diarrhea curve and the fly curve practically coinciding. This in itself is suggestive. Further, it has been demonstrated that flies are important distributors of bacteria, that they frequent localities where infective organisms are deposited, and that following eradicative measures directed toward these insects there is almost invariably a decrease in the prevalence of intestinal complaints of this character. It would therefore seem that, in the light of our present knowledge, we are warranted in the conclusion that flies play a definite rôle in the dissemination of the disease. If we wish, then, to save the lives of the babies, the very first step in the process is the eradication of flies.

Cholera and dysentery, which are primarily intestinal affections conveyed in the same manner as typhoid, are unquestionably at times disseminated by flies. Each is a bacterial disease due to a specific organism, the development of which follows the ingestion of water or food contaminated in some way from the discharges of a person ill with the disease or who excretes the bacilli thereof. It is reasonable to suppose that in a certain percentage of cases flies may act as the distributing agent, and this has been well established with the first-mentioned infection. Fortunately, cholera is a rare affliction in this country, originating only from imported cases, but epidemics of dysentery are not uncommon, being especially prevalent in institutions, camps, and districts where insanitary conditions prevail.

In addition to the intestinal diseases cited, certain other affections, more or less closely related thereto, may at times develop as a result of the activities of flies. Paratyphoid, a first cousin of typhoid fever, and food poisoning are to be considered in this category. More important still, however, are the numerous parasitic worms, such as the various species of tapeworm, hookworms, and even those of rarer forms, all of which are continued through the media of ova or eggs contained in the feces of infected persons. Many species of flies are attracted by the ova of such worms and readily devour them, with the possibility of passing through the fly undigested, with later transference to articles of food and thence to the mouths of persons, thus completing the cycle from man to man. It is believed that a certain percentage of cases of infection with intestinal parasites have their origin in this manner. Not only this, but it has been shown that flies developing from larvae which have fed on parasitic worms may harbor the immature forms of the parasites for several days in the intestinal tract, subsequently to scatter them broadcast.

A most interesting disease in which it is clearly established that flies act as the sole agent of transmission is sleeping sickness, this being an example of conveyance by inoculation. The infection is due to the invasion of the blood and body fluids by a parasite known as a trypanosome, which lives and multiplies

after it has once been introduced. Analogous parasites exist in the bodies of mammals other than man. Rats, for example, are frequently found to harbor a species of trypanosome, but curiously no symptoms develop. In this case the rat flea or rat louse is supposed to be the agent of transmission. A second variety of trypanosomes inhabits the blood of horses and other domesticated animals, producing a disease known as surra, an infection of serious economic importance in Asia, the Philippines, and other tropical countries. For many years the natives of India have ascribed the disease to the bites of insects, and at present it is all the more probable that certain species of bloodsucking flies are the responsible agents. Still another variety of trypanosome is seen in the horses, cattle, and domesticated animals of Africa. The disease as manifested in horses is known as nagana, and infected animals either die suddenly or are rendered useless to their owners as a result of deterioration through emaciation or weakness. Nagana is known to be transmitted by various species of biting flies.

In man, sleeping sickness, or trypanosomiasis, is a slowly fatal infection, recovery being very rare. The disease affects the natives of certain districts of central Africa, entire areas having been depopulated as a consequence of its ravages. It can be contracted only from a person harboring the parasites, but as the early stages of the infection are practically symptomless, frequent opportunities for its spread are afforded. The insect transmitter is a species of biting fly known as the tsetse-fly, which inhabits the shores of lakes and streams in that locality. Upon biting an infected person the insect absorbs the parasites, which then undergo certain changes within the body of the fly, and are subsequently inoculated into healthy persons, who, after a prolonged illness, ultimately die of the infection.

In addition to the diseases cited there are numerous other conditions where the possibility of fly transmission has at least been considered, although definite proof has been difficult to obtain of the truth of the theories advanced. In the majority of such conditions infective secretions capable of being transferred through the action of flies, either directly or through the medium of food, to healthy persons, are present. Tuberculosis may be mentioned as an example of such condition. Access to tuberculosis sputum by flies is not only disgusting from an aesthetic standpoint, but potentially, at least, of serious danger. The infectious disease of the eyes, trachoma, particularly as seen in Egypt, is unquestionably conveyed at times by these insects. Tropical sore, a serious and mutilating ulcerative disease occurring in various sections of South America, is not improbably disseminated by flies, and it is also believed that yaws, a somewhat similar disfiguring disease accompanied by infective secretions, may at times be spread in this manner. Mention should also be made of anthrax, which only occasionally affects man, but is rapidly fatal to cattle and sheep, and therefore of importance to the farmer. The spores of this organism are extremely difficult to kill, and it is believed that they may live in the intestinal tract of flies for days, to be later inoculated into healthy stock through the avenue of open sores or abrasions. Still another infectious disease propagated through the agency of flies is phlebotomous fever, found only in districts where that most pestiferous of all insects, the sand fly, abounds, and due directly to its bite.

Before the subject of disease transmission by flies is dismissed a remaining condition should be mentioned. This is myiasis, or, in other words, the invasion of wounds, body cavities, or the alimentary tract of man or animals by the larval forms of any species of fly. This condition, while rare where the ordinary rules of cleanliness are observed, is not at all unusual among those of filthy habits or those who are subject to neglect, more especially the residents of tropical countries. Of the cavities selected the ears and nose, particularly if abnormal secretions are present, are most apt to be the sites involved. Sleeping in exposed places accessible to insects predisposes to the condition. Neglected wounds, if accompanied by purulent discharges, may be the seat of lesions resulting from the activities of larvae developing from eggs deposited by the female fly. In the same manner larvae may develop in the alimentary tract of animals, and even of man, causing not only uncomfortable but serious symptoms. There are certain varieties of flies where a portion of the developmental cycle is ordinarily passed in the alimentary tract of animals, the eggs being deposited upon the hair. Upon the development of the larvae a slight amount of irritation results, which causes the animal to lick the spot, thus introducing the larvae into the stomach, where they attach themselves to the mucous membrane until they are ready for pupation.

Enemies of Flies.

Before consideration is given to the subject of fly control, brief mention should be made of the natural enemies of flies and the diseases from which they suffer, inasmuch as the number of insects is frequently affected through the operation of such causes. Unfortunately, the natural enemies are few and those which do exist are scarcely under the control of man. Among the enemies to be mentioned are lizards, toads, spiders, certain species of wasps, and robber flies, all of which devour flies whenever they approach within reach. The lizards and toads are particularly good flycatchers, but naturally the combined effect of all these enemies upon the total fly population is almost negligible. The enemies of the larvae are, however, much more successful in their inroads. First place should, of course, be given to the birds, which eagerly devour both the larval and adult forms. The scratching barnyard fowl is a worthy enemy, and certain forms of beetles and ants also feed industriously on both larvae and pupae of nearly all varieties. On the whole, the natural enemies of both the larval and adult forms fail to effect an appreciable reduction in the fly population.

The diseases of the fly family are seemingly much more deadly, but here again man is unable to take advantage of their presence. There are a number of parasites which are probably annoying to their hosts, but not especially destructive, and there are also certain mites which attach themselves to flies for migratory purposes. These are merely of scientific interest. Other parasites, including several species of worms, invade the internal organs. Altogether, the truth of the trite saying of Swift regarding fleas—

> So naturalists observe a flea
> Hath smaller fleas that on him prey;
> And these have smaller still to bite 'em,
> And so proceed ad infinitum.

is equally applicable to the various members of the fly family.

Adult flies are subject to at least one disease which makes serious inroads upon the insect population. Probably most of us have noticed late in the summer season dead house flies attached to ceilings or articles of furniture. Upon close inspection they may be found to have a whitish discoloration upon the abdomen or the entire fabric of the fly may appear to be disintegrated. The white material observed is the remains of a fungus known as the house-fly fungus or empusa. The fungus is more frequently observed in insects which have adopted an indoor life, but it also attacks those living under outside conditions. The disease is probably derived from insects similarly affected and first invades the body through either minute openings or the respiratory channels, gradually encroaching upon and destroying the internal organs and causing death within a few weeks of its appearance. The infection is especially prevalent from August to October and accounts, in large part, for the great reduction in the number of flies during the latter part of the season, literally millions of insects being destroyed at this period. It is a matter of regret that the disease does not manifest itself earlier in the season and that it is a condition as yet beyond the control of man, otherwise the fly problem might be capable of easy solution.

Eradicative Measures.

The most successful method of ridding a community of flies is to institute a continued campaign for that purpose. It is only by the united efforts of all residents, supplemented by the support of the health department and civic organizations in general, that progress in fly eradication is possible. This does not mean that individual effort is to be entirely subordinated or submerged, or that cleanliness of single premises is not of value, but only that the problem should be attacked as a whole and that the united effort of every citizen is necessary for its solution. When this is obtained, and the measures for fly prevention are carefully outlined, the actual work may be undertaken.

The time of the year has an important bearing upon the success of such a movement. Ordinarily fly-eradicative campaigns are instituted too late in the season to be effective. The best results are obtained if the work is begun in April, or in southern latitudes even in March, and not postponed until the natural increase in the fly population renders eradicative measures futile. The chances of success of any campaign diminish rapidly as the summer months pass. Fly prevention is much more successful than fly eradication, and this aspect of the question should constantly be borne in mind.

Of the measures to be recommended, those which aim to control the development of the larvae hold first rank, while those instituted against adult flies are usually far less successful. As long as fly-breeding areas exist it is useless to undertake suppressive measures of other character; therefore effectual control of these places is the first requisite. This means that the highest standards of community cleanliness must prevail, that accumulations of refuse and rubbish must be avoided, and that proper disposal of garbage and waste must be provided. When it is realized that even small amounts of material of this nature may serve for the development of innumerable larvae, the importance of its removal can be realized.

As horse manure constitutes the favorite breeding place for flies, its pro-

tection from adult insects is essential. Provision should be made in stables for its reception in either closed or screened bins, preferably the former. These bins should be made of cement or wood and should be properly drained in order to avoid the development of unpleasant odors. Where a small amount of manure is handled covered cans may be used. For large manure heaps the form of larval trap consisting of a raised platform a foot or more in height, covered only with slats, has been recommended. Beneath the platform is a concrete tank, holding about 2 inches of water, with plugged inflow and outflow pipes. The manure is placed on the slats and is entirely accessible to flies, but when the larvae reach the migratory stage they leave the manure, fall into the water, and are drowned. The cement basin should be flushed out at least twice a week for purposes of cleanliness and to prevent the breeding of mosquitoes, and the manure should be kept fairly moist. It is estimated that fully 99 per cent of the developing larvae may be killed in this manner.

On the farm the problem of manure disposal is not at all simple. Accumulations of animal excreta are largely unavoidable and flies even may breed in manure distributed on the soil for fertilizing purposes, although if the material is well pulverized this is less likely to occur. Where it is impossible to properly protect manure piles, treatment with certain vegetable and chemical products, with the idea of destroying both the eggs and larvae, is to be recommended. Of such substances, borax is probably the best, applied either in solution or sprinkled over the manure and then moistened with water. The development of both the eggs and the larvae is inhibited. Unfortunately, the borax contained in manure so treated may injure certain soils, especially if used in an excessive amount; therefore the quantity should not be too liberal. The Department of Agriculture estimates that if the amount does not exceed 1 pound to every 16 cubic feet of manure and that if not more than 15 tons of the treated material is applied to the acre no damage will result. There are a number of other substances adapted to this same purpose. Chloride of lime, or bleaching powder, if applied in liberal quantities, not only prevents access of flies but also the development of the larvae. However, it is directly injurious to the manure, as it interferes with its fertilizing power. If used, the dry powder should be sprinkled upon the mass. Hellebore, also used for the destruction of potato bugs, is fairly efficient. For every bushel of manure an ounce of the powder should be mixed with 1 gallon of water, and after standing for a day or two sprinkled on the pile. Another substance which has been used with beneficial results is sulphate of iron, 2 pounds per gallon of water, this being sufficient to properly treat the manure from one horse for a day. Kerosene, which has had extensive use for this purpose, has but little effect upon the fly larvae and is decidedly injurious to the manure.

If manure can neither be protected nor treated, its frequent removal becomes necessary. Under ordinary conditions the entire life cycle of the fly occupies only eight or nine days, but from the time the egg is deposited until the larval migratory stage is reached but four days are required. For this reason it is essential that the manure be removed at least every four days if fly breeding is to be prevented. The same rule applies to collections of refuse, organic waste, decaying vegetable matter, and street sweepings. If material of

this nature remains exposed for a longer period than four days it necessarily becomes a breeding spot for flies. Its removal and early destruction is therefore to be urged. While fairly good results may attend the treatment of organic wastes and refuse in a similar manner as that recommended for manure, it would be quite unwise to adopt such a course when more practicable measures are at hand.

Next to stable manure the outhouse or privy of rural communities deserves attention. House flies which develop in or frequent human excrement are many times more dangerous than those which frequent other filthy areas; therefore every effort should be made to eliminate this particular source of flies. Fortunately this is not a difficult procedure. While many types of sanitary privies have been devised (see Public Health Bulletins Nos. 51 and 68), all should have the one common provision of preventing the ingress of insects. This is best accomplished by screening. Every aperture should be thoroughly protected in this manner, and if openings exist either in the masonry or woodwork they should be closed. The seat should be self-closing, and if ventilating openings are present in the receptacle or other portion they should be properly screened. The same principles apply to latrines in camps or wherever human excrement is deposited.

The proper disposal of garbage has been already referred to. It is best that all household refuse be kept in water-tight metal cans having accurately-fitting lids, not only to prevent access of flies, but of other vermin as well. Collections of rubbish about the yard are responsible for much of the fly breeding, and public dumps may also constitute a prolific source of these insects. If these accumulations are permitted, fly breeding is inevitable.

Of the measures directed against adult flies, screening is most suitable. The unscreened house and the unprotected privy constitute a menace which no family should tolerate. It is of course well recognized that screens do not keep out all flies, but if the screening is properly done certainly 95 per cent of flies are prevented from entering and the danger is therefore reduced by just that percentage. If the owner is unable to protect the entire house in this manner, the lower floor should be given the preference, principally because flies are most numerous at that level, and it is the place where food is prepared. If not more than one or two rooms are to be screened, the kitchen and dining-room should be selected. In the case of sickness the sick room should by all means be protected, particularly if the disease is infectious, and in farming communities the dairy should receive similar attention. For persons sleeping out-of-doors where flies abound, screening is not inadvisable. It is also just as necessary that flies should not have access to markets, bakeries, and other places where food products are exposed. Whenever screening is instituted it should serve the double purpose of keeping out mosquitoes as well as flies; therefore a No. 16 mesh wire should be employed.

The devices for ridding rooms of flies are many, varying from traps, poisons and papers to fumigation. Most of these procedures are objectionable in one way of another and many are ineffective. The most common form of trap is the conical or cuboidal wire-gauze affair, baited with saccharine substances and arranged in such a manner that the insect passes through a small opening into

a large space from which he is unable to emerge. As traps go, they are generally effective, but flies, like all other animals, are often reluctant to enter places from which they can not escape.

Of substances poisonous to flies, formalin is perhaps most useful. It should be diluted with about 40 parts of water and placed in saucers about the room, at the same time removing all other liquids. After being denied all fluids for several hours the flies will drink the formalin solution and die, but the success of the plan is wholly dependent upon the complete removal of other liquids. A modification of this plan is to make the dilution with milk, placing a piece of bread in the saucer on which the flies may alight.

Of other fly poisons mention should be made, merely for the purpose of condemnation, of those composed of arsenic. Fatal cases of the poisoning of children through the use of such compounds are far too frequent, and owing to the resemblance of arsenical poisoning to summer diarrhea and cholera infantum, it is believed that the cases reported do not by any means comprise the total. Arsenical fly-destroying devices must therefore be rated as extremely dangerous and should never be used, even if other measures are not at hand.

Sticky fly papers are fairly efficacious in reducing the number of flies, even though they are not a mark of good housekeeping. They are, of course, disgusting to the eye and unless carefully handled serve to contaminate objects with which they come in contact. Fumigation with sulphur dioxide gas, generated by burning ordinary brimstone, is a valuable insecticidal measure, but unfortunately is injurious to fabrics and to painted and other surfaces. The sulphur should be used in quantities not less than 1 pound per 1000 cubic feet of space, moistened with alcohol, and ignited, care being taken that the metal container is placed in a pan of water. Pyrethrum, or insect powder, may also be burned, but it is expensive and only temporarily stupefies the insects.

Fly-swatting campaigns, of themselves, are not sufficient for the elimination of flies. Usually they are inaugurated only at the height of the fly season when a perceptible diminution in the number of insects present is not possible. If instituted during the early spring months, when the insects from which the millions of others are to be derived are few in number, some benefit may follow, particularly if precautionary measures are also exercised in regard to breeding places. If the energy displayed in late-season fly-killing campaigns could only be directed into proper channels during the early spring months, and if the people would realize that strict cleanliness and the immediate destruction of all filth and garbage are essential throughout the year, the fly problem would be largely solved.